NACA

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Navy Department

PRELIMINARY RESULTS OF ALTITUDE-WIND-TUNNEL INVESTIGATION OF X24C-4B TURBOJET ENGINE

I - PRESSURE AND TEMPERATURE DISTRIBUTIONS

By William R. Prince, and W. Kent Hawkins

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

Pressures and temperatures throughout the X24C-4B turbojet engine are presented in both tabular and graphical forms to show the effect of altitude, flight Mach number, and engine speed on the internal operation of the engine. These data were obtained in the NACA Cleveland altitude wind tunnel at simulated altitudes from 5000 to 45,000 feet, simulated flight Mach numbers from 0.25 to 1.08, and engine speeds from 4000 to 12,500 rpm. Location and detail drawings of the instrumentation installed at seven survey stations in the engine are shown.

Application of generalization factors to pressures and temperatures at each measuring station for the range of altitudes investigated showed that the data did not generalize above an altitude of 25,000 feet. Total-pressure distribution at the compressor outlet varied only with change in engine speed. At altitudes above 35,000 feet and engine speeds above 11,000 rpm, the peak temperature at the turbine-outlet annulus moved inward toward the root of the blade, which is undesirable from blade-stress considerations. The temperature levels at the turbine outlet and the exhaust-nozzle outlet were lowered as the Mach number was increased. The static-pressure measurements obtained at each stator stage of the compressor showed a pressure drop through the inlet guide vanes and the first-stage rotor at high engine speeds. The average values measured by the manufacturer's instrumentation were in close agreement with the average values obtained with NACA instrumentation.

INTRODUCTION

An investigation to determine the performance and the operational characteristics of the X24C-4B turbojet engine has been conducted in the NACA Cleveland altitude wind tunnel at the request of the Bureau of Aeronautics, Navy Department. The investigation was conducted over a wide range of simulated altitudes, flight Mach numbers, and engine speeds.

Instrumentation was installed at eight stations in the engine in order to determine the component performance as well as the over-all engine performance. Location and details of the instrumentation installed at seven survey stations in the engine are presented. Typical pressure and temperature profiles are also presented for each measuring station in the engine to show the effect of altitude, Mach number, and engine speed on the flow through the engine. Data in tabular form are presented to show the average pressures and temperatures throughout the engine for the range of conditions investigated.

APPARATUS AND INSTRUMENTATION

Engine

The X24C-4B engine used in this investigation (fig. 1) has a static sea-level rating of 3000 pounds thrust at an engine speed of 12,500 rpm. At this rating the air flow is approximately 58.5 pounds per second, the fuel consumption is 3200 pounds per hour, and the compressor pressure ratio is 3.8. The over-all length of the engine is $119\frac{1}{2}$ inches, the maximum diameter is $28\frac{1}{4}$ inches, and the total weight is 1150 pounds. The main components of the engine include an 11-stage axial-flow compressor, a double-annulus combustion chamber, a two-stage turbine, and a fixed-area exhaust nozzle.

Air enters the engine through an annular inlet and passes into the compressor through a single row of inlet guide vanes. The compressor rotor consists of a single forging with 10 disks to which the rotor blades are attached. The eleventh rotor stage is a separate disk that is fitted on a stub shaft of the main rotor and is bolted to the tenth-stage disk. The turbine shaft is connected to the eleventh-stage disk by a splined sleeve coupling. The compressor casing is horizontally divided into halves, each of which consists of a forward and rear section.

The air is discharged from the compressor through two rows of straightening vanes into a diffuser section ahead of the combustion-chamber inlet. Air entering the double-annulus combustion chamber (fig. 2) is divided into three annular streams by two concentric fuel manifolds. A screen having a 60-percent blocking area was installed in the outer annulus and one having 40-percent blocking area was installed in the intermediate annulus. Air passes through wall perforations in the combustion chamber and into the combustion zone. Fuel is injected into the annular regions of the combustion chamber from the two manifolds. The outer manifold ring has 36 fuel nozzles and the inner manifold has 24. Each fuel nozzle has a spray angle of 80° and a capacity of $7\frac{1}{2}$ gallons per hour at a differential pressure of 100 pounds per square inch.

The gases from the combustion chamber flow through the two-stage turbine into the tail pipe. Each turbine stage consists of a stator and a rotor. The turbine-rotor assembly consists of a shaft and two separate disks. The first-stage disk is bolted to the turbine shaft and the second-stage disk is bolted to the first-stage disk. The turbine shaft is hollow to accommodate a long extension bolt that secures the turbine and compressor rotors.

The compressor and turbine rotors are supported on three bearings. A single-row ball thrust bearing is located at the forward end of the compressor rotor; radial loads are carried by two roller bearings, one at the aft end of the compressor and the other just ahead of the turbine disk.

An accessory-drive gearbox is mounted at the front-bearing support on the bottom of the engine. Power to drive the accessories is provided by a vertical shaft that passes from the main rotor through the hollow front-bearing support to the gearbox.

The accessory-drive gearbox and the three engine bearings are lubricated by a solid oil system. An oil cooler is mounted forward of the front bearing support and forms a part of the engine inlet.

The main components of the fuel and fuel-control system include an all-speed hydraulic-type governor, fuel manifolds and nozzles, and a fuel-dump valve. The governor, which comprises in a single unit the fuel pump and control mechanism, is designed to maintain a constant engine speed for a fixed throttle setting regardless of flight speed or altitude. The fuel-dump valve is designed to drain the fuel manifold of residual fuel when the engine is stopped.

The starter is mounted at the forward end of the compressor rotor. Ignition is obtained by means of two spark plugs that extend into the outer annulus of the combustion chamber downstream of the fuel nozzles. A timing control limits the starting cycle to a period of 30 seconds.

Installation and Instrumentation

The engine was installed in a wing nacelle, which was supported in the 20-foot-diameter test section of the altitude wind tunnel by the tunnel balance frame (fig. 1). The engine was supported in the wing by two self-alining ball and socket mounts located on each side of the fuel manifold and by a tie bolt on the top of the front-bearing support.

For the part of the investigation reported herein, inlet pressures corresponding to high flight Mach numbers were obtained by introducing dry refrigerated air from the tunnel make-up air system through a duct to the engine inlet. This air was throttled from approximately sea-level pressure to the desired pressure at the compressor inlet while the tunnel pressure corresponding to the desired altitude was maintained. The make-up air duct was connected to the engine intake duct by means of a labyrinth slip joint, which permitted engine-thrust and installation-drag measurements to be made with the tunnel scales.

For the wind-tunnel investigation, an extended tail pipe $20\frac{1}{2}$ inches in diameter and 34 inches long was attached to the downstream flange of the main exhaust-nozzle casing. An exhaust nozzle 20 inches long having an exit area of approximately 183 square inches was attached to the downstream end of the tail pipe.

Temperature and pressure measurements were obtained at eight stations in the engine (fig. 3). Detail drawings of the instrumentation at each measuring station throughout the engine are presented in figures 4 to 14 with the exception of the compressor stator-stage static-pressure tubes at station 3. All transverse sections are shown as viewed looking aft. The survey rakes at each measuring station are numbered in a clockwise direction starting at the top of the engine.

PROCEDURE

Pressures and temperatures throughout the engine were measured at pressure altitudes from 5000 to 45,000 feet, simulated flight Mach numbers from 0.25 to 1.08, and engine speeds from idling speed, 4000 rpm, to rated speed, 12,500 rpm. For most test conditions, the inlet-air temperature was held at approximately NACA standard values corresponding to the simulated flight conditions. At the higher altitudes, the minimum engine speed was sometimes limited by combustion blow-out and the maximum engine speed by a turbine-outlet temperature of 1250° F at the hottest thermocouple.

Temperatures were measured and recorded by two self-balancing potentiometers. Pressures were measured by water, alkazine, and mercury manometers and were photographically recorded. The engine speed was set by use of a stroboscopic tachometer. Throughout the investigation AN-F-28 fuel and AAF 3606 oil were used.

RESULTS AND DISCUSSION

Average values of total and static pressures and indicated temperature throughout the engine for the range of conditions investigated are presented in table I. The average values measured by the manufacturer's instrumentation were in close agreement with the average values obtained with NACA instrumentation. All temperature values presented are indicated temperatures.

Data are presented to show the effect of altitude, flight Mach number, and engine speed on pressure and temperature distributions throughout the engine. The effect of altitude at a Mach number of approximately 0.53 and a corrected engine speed of approximately 11,855 rpm is shown in figures 15 to 22 for simulated altitudes from 15,000 to 45,000 feet. The effect of Mach number at an altitude of 25,000 feet and an engine speed of 12,000 rpm is shown in figures 23 to 30 for Mach numbers of 0.53, 0.87, and 1.08. The effect of engine speed at a Mach number of approximately 0.53 and an altitude of 25,000 feet is presented in figures 31 to 38 for engine speeds of 8000, 11,000, and 12,450 rpm. The engine speeds at which the effects of altitude and Mach number are shown were the maximum speeds at which data were obtained over the complete range of conditions.

Effect of Altitude

Data showing the altitude effect on pressure and temperature distributions at each measuring station in the engine have been generalized by use of the factors δ and θ. Pressure measurements were divided by δ, the ratio of absolute total pressure at the compressor inlet to absolute static pressure corresponding to NACA standard atmospheric conditions at sea level. Temperature measurements were divided by θ, the ratio of absolute indicated total temperature at the compressor inlet to absolute static temperature of NACA standard atmospheric conditions at sea level.

In the development of the factors δ and θ, the component efficiencies of the engine were assumed to remain constant at all altitudes. Thus a change in the generalized values of temperature and pressure with change in altitude indicates a change in engine-component efficiency. Data showing the average pressure profile through the engine have not been generalized.

Engine profile. - The variation of average total and static pressures at each measuring station through the engine for several altitudes is shown in figure 15. A continuous pressure rise was obtained throughout the stages of the compressor.

Cowl inlet. - Corrected total- and static-pressure and corrected temperature distributions at the cowl inlet (fig. 16) were very uniform across the duct and were unaffected by changes in altitude. The boundary layer at the wall was approximately 1 inch chick.

Compressor inlet. - Altitude had no appreciable effect on radial or circumferential distributions of corrected pressure and temperature at the compressor inlet (fig. 17). The corrected static-pressure and corrected temperature distributions across the inlet were uniform and unaffected by changes in altitude. The corrected total pressure was uniform across the inlet with the exception of a 1-inch boundary layer at the annulus inner wall and a $1\frac{1}{2}$-inch boundary layer at the annulus outer wall.

Compressor outlet. - The effect of altitude on the radial distribution of corrected total pressure and corrected temperature at three rakes located 120° apart at the compressor outlet is shown in figure 18. Only the average corrected static pressure at each rake is indicated because for all conditions there was no appreciable radial or circumferential variation in static pressure

at the compressor outlet. For a distance of about 3/4 inch from the inner wall of the passage, the corrected total pressure and the corrected average static pressure were approximately equal. From this point the pressures increased rapidly across the passage and peak pressures were obtained approximately 3/4 inch from the outer wall. The circumferential distribution of these peak pressures was uniform for each altitude. The distribution of corrected total pressure, static pressure, and temperature for the three rakes was approximately the same for altitudes of 15,000 and 25,000 feet. As the altitude was increased above 25,000 feet, the corrected pressures and temperatures increased. This increase denotes a reduction in engine-component efficiency for altitudes above 25,000 feet.

Turbine inlet. - The effect of altitude on the circumferential distribution of corrected total pressure at the turbine inlet is shown in figure 19. The values measured by the manufacturer's integrating total-pressure rake were in close agreement with the values measured by the individual NACA total-pressure tubes. The circumferential pressure distribution was very uniform at each altitude because of the screens at the combustion-chamber inlet. Use of generalization factors corrected the pressures at altitudes of 15,000 and 25,000 feet to approximately a single curve, but above 25,000 feet the pressure increased as the altitude increased. This trend is similar to that at the compressor outlet (fig. 18).

Turbine outlet. - Radial pressure measurements obtained at the turbine outlet are shown in figure 20 for several altitudes. The average corrected static pressure is presented inasmuch as static-pressure measurements were confined to wall orifices. The corrected total pressure increased uniformly across the passage from inner to outer wall for all altitudes except 45,000 feet. At 45,000 feet the total pressure was uniform across the passage to within 1-inch of the outer wall, beyond which a rise in pressure occurred. The corrected pressures failed to generalize above 25,000 feet, as was the case at the compressor outlet and the turbine inlet. Data are shown for only one of the two pressure rakes, because no measurements were obtained with the other rake.

The radial distribution of corrected temperature at the turbine outlet is presented in figure 21(a) for three rakes located at 47°, 180°, and 300°, measured clockwise from the top of the engine. Except for the data obtained at 45,000 feet, the change in altitude had little effect on the radial temperature distribution. At 45,000 feet there was indication that the temperature near the inner wall increased with respect to the temperature

near the outer wall. From blade-stress considerations, it is desirable to have the lowest temperature at the roots of the blades and the peak temperature about 1/2 inch from the blade tips.

The circumferential corrected temperature distribution for two radial positions at the turbine outlet is shown in figure 21(b). Values for the two circumferential temperature distributions were obtained from data measured by six NACA single thermocouples and three manufacturer's shielded single thermocouples located 1.75 and 2.00 inches, respectively, from the tail-pipe outer wall. These thermocouples were in some cases located at radial positions that differed from those in the survey rakes. Thus where the radial positions differ from the aforementioned locations, only faired values obtained from rake measurements are presented in figure 21(b). Large circumferential temperature variations occurred at both radial positions at the turbine outlet. An inspection of the turbine stator blades showed definite discolorations around the stator circumference, which indicated the presence of the temperature irregularities shown at the turbine outlet. Changes in altitude up to 35,000 feet had very little effect on the circumferential corrected temperature distribution. For an altitude of 45,000 feet, the decrease in temperature at the top of the turbine outlet was probably due to the fact that the fuel flow was less from the top fuel nozzles. The difference in head of fuel between the top and the bottom of the manifold, together with the low fuel-manifold pressure accompanying high-altitude operation, resulted in decreased fuel flow and poor atomization from the top nozzles.

Exhaust-nozzle outlet. - At the exhaust-nozzle outlet (fig. 22), the corrected total-pressure distribution for all altitudes was reasonably symmetrical about the center line of the jet. Total pressures at the center of the jet, however, were considerably lower than at the wall of the exhaust nozzle. The corrected temperature at the center of the jet was slightly lower than at the wall at all altitudes except 45,000 feet. The change in temperature pattern at 45,000 feet showing the decreased temperature in the upper part of the exhaust nozzle was due to poor fuel distribution at high altitudes. Static-pressure distribution was measured over the lower portion of the exhaust-nozzle outlet. The lowest values of corrected static pressure occurred at the bottom wall.

Effect of Flight Mach Number

Data showing the effect of Mach number on pressures and temperatures through the engine are actual measured values and have

not been corrected for any variation in temperature conditions at the compressor inlet from the desired free-stream total temperatures corresponding to the respective flight Mach numbers.

Engine profile. - The effect of Mach number on the average total and static pressures at each measuring station in the engine is shown in figure 23. Increasing the Mach number from 0.53 to 1.08 did not appreciably affect the general pressure distribution. At each Mach number, the static pressures at the first and second stages were slightly lower than the compressor-inlet static pressure (station 2), evidently because of the pressure loss through the inlet guide vanes and the first-stage rotor. Beyond the second stage a continuous rise in pressure through the compressor was obtained. As would be expected, an increase in Mach number increased the over-all pressure level through the engine.

Cowl inlet and compressor inlet. - Pressure and temperature distributions at the cowl inlet and the compressor inlet were very uniform for the range of Mach numbers investigated (figs. 24 and 25). At both stations the total pressures near the walls decreased due to the boundary layer. The temperature at the compressor inlet was maintained at the desired value for only the Mach number of 0.53. A comparison of the desired temperature with the actual measured temperature is given in the following table:

Mach number	Desired compressor-inlet total temperature T_2, (°R)	Actual compressor-inlet temperature $T_{1,2}$, (°R)
0.53	453	454
.87	493	500
1.08	528	505

Compressor outlet. - The effect of Mach number on the radial distribution of total pressure and temperature and average static pressure at the compressor outlet is shown in figure 26. The radial total-pressure distributions across the annular passage were not appreciably affected by changes in Mach number except near the outer wall. As the Mach number was raised, the total pressure at the outer wall became less than the peak total pressure. As noted in the discussion of altitude effect, the total and static pressures near the inner wall were approximately equal and the peak total pressure in most cases was measured approximately 3/4 inch from the

outer wall. The variation of temperature level with Mach number at the compressor outlet was similar to that at the compressor inlet (fig. 25).

Turbine inlet. - The circumferential total-pressure distribution at the turbine inlet (fig. 27) was very uniform for the range in Mach numbers. Values measured by the NACA pressure tubes and the manufacturer's pressure integrating rake showed close agreement in all cases.

Turbine outlet. - The radial variation of total pressure and average static pressure at the turbine outlet with change in Mach number is presented in figure 28. An increase in Mach number did not change the radial total-pressure distribution. The total pressure at the outer wall at each Mach number was slightly higher than at the inner wall.

The effect of Mach number on the radial temperature distributions measured by the three rakes at the turbine outlet is shown in figure 29(a). The radial temperature distribution was not appreciably affected by change in Mach number. However, the indicated temperatures at the turbine outlet decreased with increasing Mach number.

The circumferential temperature variations for two radial positions at the turbine outlet are shown in figure 29(b). Close agreement is shown between the temperature patterns at both radial positions. The circumferential distribution was not appreciably affected by change in Mach number.

Exhaust-nozzle outlet. - Pressure and temperature distributions at the exhaust-nozzle outlet for the range of Mach numbers investigated are presented in figure 30. The total-pressure distributions were similar in all cases and approximately symmetrical about the center line of the jet. The temperature measurements over the upper portion of the exhaust-nozzle outlet showed slightly lower values at the center of the jet than near the wall. The temperature distributions were similar for the range of Mach numbers investigated. At this station as well as at the turbine outlet, an increase in Mach number resulted in a reduction in indicated temperature. The static-pressure distributions measured over the lower portion of the exhaust-nozzle outlet and at wall orifices were similar for all Mach numbers investigated, the lowest values occurring at the wall.

Effect of Engine Speed

Engine profile. - The effect of engine speed on the average total and static pressures at each measuring station through the engine is shown in figure 31. The static-pressure measurements obtained at each stator stage of the compressor show a pressure drop through the inlet guide vanes and the first-stage rotor at an engine speed of 12,450 rpm that was not encountered at 8000 rpm and was only slightly noticeable at 11,000 rpm.

Cowl inlet and compressor inlet. - Pressure and temperature distributions at the cowl inlet and the compressor inlet were very uniform, except for the boundary layer, throughout the range of engine speeds investigated (figs. 32 and 33). The boundary layer increased with increase in engine speed because of the higher inlet velocity.

Compressor outlet. - The radial distribution of total pressures and temperatures at the compressor outlet is shown in figure 34. Only the average static pressure at each rake is indicated, because for all engine speed conditions there was no appreciable radial or circumferential variation in static pressure at the compressor outlet. The total-pressure distribution was reasonably uniform at an engine speed of 8000 rpm. At an engine speed of 11,000 rpm, a total-pressure peak occurred approximately 3/4 inch from the outer wall, whereas at the inner wall the total and static pressures remained approximately equal. As the engine speed was increased, the total-pressure peak increased in magnitude and moved nearer the outer wall with total and static pressures remaining approximately equal at the inner wall. The circumferential variation in total pressures for the range of engine speeds investigated was very slight.

Turbine inlet. - The circumferential variation in total pressures at the turbine inlet with change in engine speed is shown in figure 35. The total-pressure distribution was uniform at each engine speed and the measurements made with NACA pressure tubes were in close agreement at all engine speeds with measurements made with the manufacturer's total-pressure integrating rakes.

Turbine outlet. - The effect of engine speed on total-pressure distribution at the turbine outlet is shown in figure 36. The total pressures increased slightly across the passage from the inner wall to the outer wall. At engine speeds of 8000 and 11,000 rpm, no measurements were obtained from rake 1. At an engine speed of

12,450 rpm, the close agreement in data obtained with both rakes indicates that the circumferential distribution of total pressure was uniform.

The radial and circumferential temperature distributions at the turbine outlet are shown in figures 37(a) and 37(b), respectively. As the engine speed was increased the peak temperature in general shifted toward the inner wall, which is undesirable from blade-stress considerations. At an engine speed of 12,450 rpm, the peak temperatures were approximately the same for the three rakes. Large circumferential temperature variations occurred at each engine speed (fig. 37(b)) and it is believed that the distribution at the turbine inlet was even more irregular than indicated by these measurements, inasmuch as the temperature variations were reduced by mixing in passing through the turbine. Reasonable agreement is shown between the temperature patterns at both radial positions.

Exhaust-nozzle outlet. - Pressure and temperature distributions at the exhaust-nozzle outlet for three engine speeds are shown in figure 38. The total pressure was approximately constant across the nozzle outlet at an engine speed of 8000 rpm. As the engine speed was increased, a pronounced low-pressure area formed in the center of the jet.

At engine speeds of 8000 and 11,000 rpm, the temperatures near the wall of the exhaust nozzle were slightly greater than in the center of the jet. At an engine speed of 12,450 rpm, however, the temperatures were lower near the exhaust-nozzle wall than elsewhere in the jet.

At engine speeds of 8000 and 11,000 rpm, the static pressure was slightly higher at the top of the exhaust nozzle than at the bottom. At an engine speed of 12,450 rpm, the static pressure at the bottom of the nozzle was higher.

SUMMARY OF RESULTS

The following results were obtained from an investigation of the X24C-4B turbojet engine in the Cleveland altitude wind tunnel at simulated altitudes from 5000 to 45,000 feet, simulated flight Mach numbers from 0.25 to 1.08, and engine speeds from 4000 to 12,500 rpm.

1. Use of generalization factors in the presentation of the effect of altitude on the pressures and temperatures at each

measuring station in the engine showed that the data did not generalize above an altitude of 25,000 feet, which indicated a change in engine-component efficiency with increase in altitude above 25,000 feet.

2. Total-pressure distribution at the compressor outlet varied only with change in engine speed. At an engine speed of 8000 rpm, the pressure distribution was uniform across the passage. At 11,000 rpm, a total-pressure peak occurred at approximately 3/4 inch from the outer wall; whereas at the inner wall the total and static pressure remained approximately equal. At 12,450 rpm, the total-pressure peak increased in magnitude and moved nearer the outer wall while total and static pressures at the inner wall remained approximately equal.

3. At altitudes above 35,000 feet and engine speeds above 11,000 rpm, the peak temperature at the turbine-outlet annulus moved inward toward the root of the blade, which is undesirable from blade-stress considerations.

4. The temperature levels at the turbine outlet and the exhaust-nozzle outlet were lowered as the Mach number was increased.

5. The static-pressure measurements obtained at each stator stage of the compressor showed a pressure drop through the inlet guide vanes and the first-stage rotor at an engine speed of 12,450 rpm that was not encountered at 8000 rpm and was only slightly noticeable at 11,000 rpm.

6. The average values measured by the manufacturer's instrumentation were in close agreement with the average values obtained with the NACA instrumentation.

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TABLE I. - AVERAGE PRESSURES AND TEMPERATURES THROUGHOUT XB4C-4B

Run	1 Altitude (ft)	2 Ram-pressure ratio, P_2/p_0	3 Flight Mach number	4 Tunnel-static pressure, (lb/sq ft abs.)	5 Tunnel temperature, (°R)	6 Engine speed, (rpm)	7 Net thrust, F_n, (lb)	8 Cowl inlet: Indicated temperature, $T_{i,1}$, (°R)	9 Cowl inlet: Total pressure, P_1, (lb/sq ft abs.)	10 Cowl inlet: Static pressure, p_1, (lb/sq ft abs.)	11 Compressor inlet: Indicated temperature, $T_{i,2}$, (°R)	12 Compressor inlet: Total pressure, P_2, (lb/sq ft abs.)	13 Compressor inlet: Total pressure, P_2, (lb/sq ft abs.)[a]	14 Compressor inlet: Static pressure, p_2, (lb/sq ft abs.)	15 Compressor stator-stage static pressure, p_3 (lb/sq ft abs.): 1	16: 2	17: 3	18: 4	19: 5	20: 6
1	5,000	1.037	0.23	1760	528	4,000	38	514	1826	1817	512	1825	1824	1818	1830	1866	1894	1922	1943	1971
2	5,000	1.038	.23	1760	529	6,000	147	513	1827	1803	513	1826	1826	1809	1844	1908	1985	2042	2105	2168
3	5,000	1.038	.23	1760	519	8,000	419	512	1831	1779	510	1827	1828	1789	1844	1971	2105	2225	2351	2478
4	5,000	1.040	.24	1760	537	9,000	669	515	1836	1755	512	1831	1833	1773	1859	1999	2168	2380	2548	2746
5	5,000	1.037	.23	1753	541	10,000	1002	513	1831	1709	510	1817	1826	1735	1809	1957	2175	2429	2696	2943
6	5,000	1.045	.25	1753	465	11,000	1414	506	1842	1675	509	1832	1837	1712	1725	1859	2154	2471	2795	3119
7	5,000	1.050	.26	1753	465	11,500	1659	505	1845	1663	509	1840	1849	1705	1676	1795	2105	2457	2809	3161
8	5,000	1.048	.26	1767	483	12,000	1920	507	1870	1660	510	1851	1865	1706	1619	1732	2042	2415	2802	3168
9	5,000	1.051	.27	1760	488	12,500	2278	492	1872	1638	495	1850	1866	1692	(c)	(c)	(c)	(c)	(c)	(c)
10	15,000	1.037	.23	1190	439	4,000	24	458	1235	1228	460	1234	1235	1230	1232	1253	1282	1303	1317	1338
11	15,000	1.039	.23	1190	435	6,000	114	462	1238	1220	465	1236	1236	1223	1246	1303	1359	1401	1443	1493
12	15,000	1.039	.23	1190	437	8,000	326	469	1237	1199	470	1237	1238	1208	1246	1338	1436	1521	1612	1711
13	15,000	1.040	.24	1190	441	9,000	513	475	1241	1178	476	1238	1240	1193	1260	1352	1479	1605	1760	1908
14	15,000	1.043	.25	1190	441	10,000	782	469	1246	1154	473	1241	1243	1174	1218	1317	1493	1704	1866	2056
15	15,000	1.048	.26	1190	443	11,000	1092	467	1255	1130	469	1247	1251	1157	1091	1232	1436	1662	1908	2133
16	15,000	1.051	.27	1190	446	11,500	1324	466	1259	1117	469	1251	1257	1149	1084	1148	1366	1612	1873	2126
17	15,000	1.052	.27	1190	444	12,000	1473	467	1261	1108	470	1252	1258	1143	1035	1098	1310	1570	1845	2119
18	15,000	1.046	.26	1183	461	12,500	1686	473	1252	1092	475	1238	1247	1128	965	1014	1225	1493	1781	2077
19	15,000	1.210	.53	1190	522	6,000	-41	507	1442	1419	507	1440	1439	1424	1450	1514	1570	1619	1669	1732
20	15,000	1.209	.53	1197	522	8,000	119	506	1450	1403	506	1447	1446	1413	1457	1556	1655	1767	1880	1993
21	15,000	1.208	.53	1197	493	9,000	272	510	1451	1382	509	1446	1447	1398	1465	1570	1704	1852	2014	2169
22	15,000	1.210	.53	1204	503	10,000	538	409	1463	1363	507	1457	1458	1386	1436	1556	1542	1929	2133	2344
23	15,000	1.217	.54	1190	508	11,000	925	502	1457	1321	500	1448	1452	1351	1338	1443	1669	1936	2183	2443
24	15,000	1.222	.54	1197	507	11,500	1159	493	1474	1315	493	1463	1468	1352	1303	1394	1641	1922	2211	2485
25	15,000	1.221	.54	1197	514	12,000	1335	497	1471	1301	497	1461	1467	1341	1260	1331	1577	1873	2176	2471
26	15,000	1.212	.53	1190	467	12,500	1574	492	1457	1275	494	1442	1455	1319	(c)	(c)	(c)	(c)	(c)	(c)
27	15,000	1.415	.72	1190	442	8,000	-9	498	1689	1630	498	1684	1682	1642	1704	1817	1929	2063	2211	2345
28	15,000	1.420	.73	1190	440	9,000	165	497	1697	1612	499	1690	1689	1630	1711	1824	1993	2169	2359	2542
29	15,000	1.415	.72	1197	446	10,000	450	503	1702	1584	502	1694	1694	1611	1669	1802	2021	2246	2485	2718
30	15,000	1.425	.73	1190	450	11,000	909	499	1706	1547	500	1696	1700	1584	1549	1697	1971	2267	2570	2851
31	15,000	1.423	.72	1190	466	11,500	1195	492	1710	1525	494	1693	1706	1569	1514	1619	1753	2232	2556	2873
32	15,000	1.424	.72	1197	451	12,000	1449	500	1718	1520	500	1704	1711	1568	1465	1556	1852	2295	2535	2873
33	15,000	1.421	.73	1190	481	12,500	1621	512	1710	1501	514	1691	1706	1552	1408	1486	1767	2112	2478	2830
34	25,000	1.037	.23	774	439	6,000	91	442	803	791	443	803	803	795	809	844	880	915	943	971
35	25,000	1.037	.23	788	443	8,000	259	443	819	792	445	817	818	796	823	887	950	1013	1077	1147
36	25,000	1.041	.24	781	439	9,000	387	439	815	771	440	813	814	778	816	880	964	1063	1168	1281
37	25,000	1.046	.26	781	440	10,000	569	439	821	756	439	817	819	769	795	858	978	1098	1239	1372
38	25,000	1.046	.26	781	447	11,000	829	438	822	735	441	817	820	754	725	781	922	1077	1239	1408
39	25,000	1.049	.25	781	450	11,500	964	439	825	729	439	819	824	750	682	732	873	1034	1210	1393
40	25,000	1.009	.10	774	455	11,800	1094	439	788	688	439	781	785	710	661	704	844	1013	1196	1379
41	25,000	1.045	.25	781	454	12,000	1108	436	825	721	439	816	823	745	647	689	760	1006	1196	1393
42	25,000	1.045	.25	781	456	12,350	1192	439	826	720	441	816	823	744	619	661	795	985	1182	1393
43	25,000	1.210	.53	781	444	7,000	61	454	947	923	455	945	944	913	943	999	1063	1119	1182	1239
44	25,000	1.202	.52	788	445	8,000	146	453	949	915	455	947	947	922	957	1027	1098	1175	1260	1344
45	25,000	1.211	.53	774	441	9,000	275	445	941	886	446	937	937	898	936	1013	1112	1225	1344	1465
46	25,000	1.203	.52	788	436	10,000	472	450	953	877	451	948	949	894	922	999	1126	1274	1422	1576
47	25,000	1.208	.53	774	439	11,000	759	451	942	843	452	935	938	865	837	907	1056	1232	1422	1598
48	25,000	1.209	.53	781	440	11,500	938	451	952	840	454	944	948	866	(c)	(c)	(c)	(c)	1408	1612
49	25,000	1.213	.53	781	439	12,000	1056	455	954	836	454	947	950	863	760	816	964	1168	1373	1591
50	25,000	1.207	.53	781	466	12,450	1217	450	954	830	451	943	953	861	711	753	908	1119	1351	1591
51	25,000	1.428	.73	781	450	8,950	165	465	1119	1059	467	1115	1118	1072	1119	1196	1309	1436	1569	1689
52	25,000	1.417	.73	781	441	10,000	398	469	1113	1029	470	1107	1109	1047	1077	1168	1316	1478	1640	1802
53	25,000	1.428	.73	781	454	10,500	592	464	1122	1019	464	1115	1117	1042	1049	1126	1295	1478	1675	1858
54	25,000	1.420	.73	781	440	11,000	742	469	1117	1004	469	1109	1120	1029	1013	1091	1267	1471	1682	1879
55	25,000	1.402	.72	788	442	11,500	936	470	1114	987	470	1105	1108	1016	971	1041	1224	1443	1668	1893
56	25,000	1.428	.73	781	442	12,000	1103	470	1124	988	470	1115	1120	1020	922	978	1161	1386	1633	1858
57	25,000	1.424	.73	781	464	12,400	1306	460	1125	981	460	1112	1121	1015	858	901	1091	1323	1584	1844
58	25,000	1.424	.73	781	464	12,500	1334	460	1125	980	461	1112	1122	1015	851	894	1077	1316	1577	1844
59	25,000	1.634	.87	774	496	9,500	37	503	1270	1104	503	1265	1265	1210	1267	1358	1499	1647	1816	1971
60	25,000	1.624	.86	788	479	10,000	337	494	1287	1194	495	1280	1281	1215	1253	1358	1513	1696	1879	2062
61	25,000	1.629	.86	774	479	10,500	510	495	1269	1161	495	1261	1264	1185	1203	1295	1478	1682	1886	2083
62	25,000	1.626	.86	781	485	11,000	679	497	1278	1158	496	1270	1272	1186	1182	1274	1471	1696	1914	2126
63	25,000	1.625	.86	781	488	11,500	927	498	1279	1142	497	1269	1272	1173	1133	1210	1422	1661	1907	2147
64	25,000	1.633	.87	781	496	12,000	1131	500	1286	1137	500	1275	1279	1171	1084	1154	(c)	1626	1886	2147
65	25,000	1.634	.87	781	481	12,500	1351	490	1290	1127	490	1276	1286	1167	1027	1077	1288	1555	1830	2105
66	25,000	1.850	.98	781	479	8,000	-159	504	1450	1399	503	1445	1447	1410	1471	1562	1661	1774	1893	1999
67	25,000	1.841	.98	788	471	9,000	12	507	1458	1383	507	1451	1455	1399	1464	1576	1703	1865	2020	2182
68	25,000	1.837	.98	781	474	10,000	303	502	1445	1342	502	1435	1441	1365	1415	1527	1710	1907	2112	2309

[a]Manufacturer's instrumentation.
[b]Data for stage 9 not obtained.
[c]Data not obtained.

TURBOJET ENGINE WITH 183.1 SQUARE INCH EXHAUST NOZZLE

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	41	42
Compressor stator-stage static pressure, P_3 (lb/sq ft abs.)				Compressor outlet					Turbine inlet		Turbine stator-stage static pressure, P_6 (lb/sq ft abs.)		Turbine outlet					Exhaust-nozzle outlet		
				Indicated temperature, $T_{1,4}$, (°R)	Indicated temperature, $T_{1,4}$, (°R)a	Total pressure, P_4, (lb/sq ft abs.)	Total pressure, P_4, (lb/sq ft abs.)a	Static pressure, P_4, (lb/sq ft abs.)a	Total pressure, P_5, (lb/sq ft abs.)	Total pressure, P_5, (lb/sq ft abs.)a			Indicated temperature, $T_{1,7}$, (°R)	Indicated temperature, $T_{1,7}$, (°R)a	Total pressure, P_7, (lb/sq ft abs.)	Total pressure, P_7, (lb/sq ft abs.)a	Static pressure, P_7, (lb/sq ft abs.)	Indicated temperature, $T_{1,8}$, (°R)	Total pressure, P_8, (lb/sq ft abs.)	Static pressure, P_8, (lb/sq ft abs.)
7	8	b10	11								1	2								
1999	2027	2035	1985	538	537	2065	2070	2082	2017	2017	1943	1821	1076	1238	1811	1809	1781	1088	1808	1767
2246	2323	2415	2337	577	580	2513	2520	2467	2406	2408	2232	1927	1155	1281	1894	1880	1816	1134	1885	1777
2626	2774	3055	2978	632	635	3294	3309	3220	3102	3105	2786	2149	1161	1294	2060	2028	1894	1182	2042	1813
2950	3168	3576	3527	668	672	3952	3978	3854	3693	3700	3276	2368	1160	1286	2211	2182	1978	1170	2188	1840
3238	3499	4182	4133	703	710	4755	4780	4628	4426	4435	3895	2675	1180	1295	2438	2387	2091	1198	2376	1877
3471	3865	4837	5041	738	751	5703	5709	5527	5294	5308	4649	3095	1235	1393	2665	2668	2276	1242	2617	1948
3548	3999	5160	5498	756	767	6168	6146	5967	5731	5738	5024	3318	1285	1443	2841	2823	2394	1298	2774	2006
3597	4425	5535	5907	776	785	6678	6674	6451	6230	6234	5442	3593	1372	1429	3048	3013	2539	1377	2966	2091
(c)	(c)	(c)	(c)	785	789	(c)	(c)	(c)	(c)	(c)	(c)	(c)	1450	1631	(c)	(c)	(c)	1456	3189	2183
1359	1387	1401	1373	490	490	1427	1429	1412	1403	1389	1331	1234	1016	1136	1226	1225	1204	1021	1227	1197
1549	1612	1690	1648	535	537	1768	1774	1739	1681	1690	1558	1319	1055	1182	1288	1282	1232	1054	1288	1206
1817	1943	2154	2119	592	598	2347	2366	2293	2206	2211	1976	1491	1079	1219	1404	1401	1296	1097	1404	1229
2070	2232	2563	2549	634	642	2860	2880	2788	2668	2675	2361	1667	1085	1237	1525	1514	1359	1090	1517	1253
2260	2492	3013	3070	664	674	3486	3506	3390	3243	3246	2851	1924	1104	1265	1698	1697	1470	1104	1665	1291
2401	2697	3478	3717	698	708	4154	4140	4021	3863	3869	3391	2241	1188	1344	1917	1915	1614	1199	1861	1353
2422	2788	3781	4133	772	729	4550	4569	4397	4250	4256	3724	2429	1287	1433	2060	2056	1723	1294	2021	1410
2443	2844	3978	4386	738	745	4840	4809	4634	4513	4513	3938	2577	1370	1518	2162	2176	1810	1372	2122	1459
2429	2922	4668	4541	767	768	5014	5062	4834	4761	4766	4152	2720	1503	1630	2273	2281	1885	1494	2225	1504
1774	1824	1817	1641	562	564	1820	1817	1769	1706	1708	1577	1322	847	919	1300	1303	1239	854	1288	1204
2105	2211	2373	2169	621	625	2493	2499	2415	2306	2309	2058	1521	940	1032	1447	1422	1310	941	1430	1241
2330	2485	2753	2605	656	660	2989	3006	2898	2760	2767	2436	1706	992	1106	1570	1570	1380	987	1554	1267
2549	2774	3246	3196	690	695	3648	3675	3547	3377	3386	2964	1978	1045	1160	1767	1725	1498	1046	1723	1319
2711	3027	3788	3929	721	729	4475	4485	4336	4144	4154	3638	2385	1147	1275	2042	1993	1688	1145	1964	1390
2802	3168	4154	4464	737	746	4995	4985	4836	4640	4647	4064	2645	1230	1328	2262	2204	1850	1242	2170	1479
2809	3217	4358	4766	765	771	5263	5273	5080	4905	4910	4297	2793	1340	1443	2380	2316	1941	1341	2289	1537
(c)	(c)	(c)	(c)	781	785	(c)	(c)	(c)	(c)	(c)	(c)	(c)	1425	1570	(c)	(c)	(c)	1418	2432	1617
2471	2577	2704	2338	605	610	2761	2760	2644	2508	2514	2225	1591	786	827	1478	1465	1329	767	1476	1244
2725	2887	3168	2830	639	646	3369	3372	3241	3068	3077	2702	1831	851	919	1641	1626	1429	845	1634	1277
2957	3196	3689	3520	682	690	4107	4133	3981	3779	3788	3311	2178	949	1068	1875	1873	1584	937	1835	1349
3168	3506	4330	4393	720	731	5062	5090	4916	4689	4696	4107	2676	1083	1230	2241	2225	1857	1083	2188	1484
3218	3633	4696	4893	733	743	5648	5646	5462	5231	5245	4576	2981	1160	1311	2477	2459	2037	1168	2416	1600
3253	3717	4977	5407	762	773	6040	6026	5823	5606	5615	4886	3187	1280	1441	2661	2647	2192	1290	2591	1693
3232	3753	5196	5639	799	805	6337	6357	6087	5905	5911	5151	3370	1401	1539	2801	2795	2300	1402	2722	1775
1013	1063	1119	1091	514	515	1170	1175	1152	1119	1119	1032	866	1074	1258	844	837	802	1084	838	788
1284	1316	1471	1464	571	576	1615	1626	1580	1527	1517	1353	1001	1064	1242	950	936	858	1092	946	818
1386	1513	1760	1774	598	606	1986	1999	1936	1881	1855	1635	1138	1048	1204	1042	1020	908	1059	1020	830
1520	1689	2076	2154	631	642	2426	2435	2357	2253	2259	1983	1323	1084	1239	1173	1154	997	1082	1128	865
1591	1809	2421	2625	673	680	2891	2893	2795	2700	2707	2365	1550	1208	1348	1316	1316	1103	1222	1293	914
1598	1872	2597	2851	693	698	3136	3118	3003	2935	2935	2571	1670	1302	1441	1405	1415	1173	1316	1385	951
1605	1900	2689	2942	704	707	3235	3210	3082	3018	3020	2642	1722	1339	1498	1448	1450	1205	1353	1415	962
1640	1971	2830	3013	714	716	3382	3358	3204	3153	3153	2754	1797	1419	1540	1507	1513	1248	1408	1470	993
1661	2027	2942	3118	732	736	3500	3463	3297	3268	3266	2851	1865	1516	1642	1567	1562	1290	1504	1524	1021
1302	1365	1422	1316	541	547	1484	1485	1441	1377	1386	1241	950	850	945	915	901	837	841	898	804
1429	1520	1647	1541	571	576	1760	1767	1709	1630	1633	1452	1046	898	979	983	971	880	901	972	825
1591	1717	1964	1907	596	603	2180	2203	2121	2017	2020	1781	1203	932	1043	1091	1070	936	914	1061	837
1731	1907	2302	2344	637	647	2665	2682	2588	2468	2471	2166	1424	1011	1151	1246	1224	1046	1008	1199	893
1802	2041	2654	2857	677	686	3184	3182	3080	2961	2963	2592	1684	1137	1286	1443	1422	1180	1167	1389	951
1837	2126	2900	3189	704	712	3513	3520	3378	3277	3280	2870	1846	1268	1415	1580	1569	(c)	1286	1524	1016
1844	2168	3069	3372	726	730	3720	3689	3550	3468	3470	3036	1961	1369	1517	1672	1654	1360	1381	1608	1063
1886	2295	3351	3561	745	748	4002	3956	3768	3728	3731	3257	2121	1510	1642	1768	1774	1455	1497	1684	1127
1823	1943	2161	1978	608	615	2330	2337	2248	2130	2140	1874	1253	838	900	1130	1105	959	831	1103	851
1978	2154	2541	2449	651	659	2879	2900	2796	2654	2658	2325	1518	962	1071	1297	1288	1084	942	1263	984
2062	2281	2816	2879	671	679	3302	3315	3204	3059	3062	2675	1734	1036	1173	1478	1450	1208	1033	1430	972
2105	2351	2999	3153	691	701	3574	3583	3459	3306	3312	2907	1877	1103	1240	1598	1569	1300	1119	1532	1021
2147	2442	3273	3541	719	727	3934	3935	3800	3664	3667	3208	2076	1231	1362	1767	1724	1434	1242	1689	1108
2140	2485	3463	3815	740	745	4207	4202	4037	3921	3921	3430	2219	1328	1483	1880	1844	1525	1334	1803	1170
2161	2590	3766	4033	745	747	4534	4498	4277	4224	4228	3686	2398	1434	1577	1991	1999	1645	1426	1949	1264
2168	2618	3822	4083	752	754	4584	4547	4333	4273	4277	3731	2428	1469	1597	2017	2020	1661	1461	1970	1276
2126	2274	2541	2302	660	666	2746	2752	2642	2496	2506	2191	1434	856	959	1258	1232	1042	848	1207	880
2238	2428	2816	2696	673	681	3149	3160	3039	2883	2893	2525	1638	934	1001	1406	1379	1151	910	1353	945
2295	2520	3034	3034	696	703	3488	3513	3384	3216	3224	2811	1818	1018	1127	1548	1506	1255	999	1490	996
2358	2618	3245	3301	714	724	3809	3829	3692	3524	3531	3081	1994	1087	1215	1689	1654	1374	1082	1622	1067
2407	2710	3520	3752	740	749	4232	4224	4089	3919	3925	3430	2217	1202	1322	1880	1830	1520	1212	1805	1164
2435	2780	3787	3928	763	769	4575	4583	4412	4264	4270	3724	2409	1325	1441	2043	1992	1649	1329	1969	1271
2435	2865	4083	4400	774	778	4991	4949	4764	4648	4653	4052	2642	1425	1549	2183	2189	1797	1415	2133	1372
2105	2189	2231	1647	603	609	2156	2161	2044	1914	1921	1691	1156	647	662	1048	1041	915	643	1038	835
2330	2471	2661	2161	640	653	2767	2759	2635	2480	2485	2173	1426	755	789	1237	1232	1034	728	1218	891
2506	2710	3104	2816	677	684	3424	3449	3311	3134	3146	2740	1783	893	978	1489	1478	1230	868	1448	984

TABLE I. - CONCLUDED. AVERAGE PRESSURES AND TEMPERATURES THROUGHOUT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
								Cowl inlet			Compressor inlet				Compressor stator-stage static pressure, P_3 (lb/sq ft abs.)					
Run	Altitude, (ft)	Ram-pressure ratio, P_2/P_0	Flight Mach number	Tunnel-static pressure, (lb/sq ft abs.)	Tunnel temperature, (°R)	Engine speed, (rpm)	Net thrust, F_n, (lb)	Indicated temperature, $T_{i,1}$, (°R)	Total pressure, P_1, (lb/sq ft abs.)	Static pressure, p_1, (lb/sq ft abs.)	Indicated temperature, $T_{i,2}$, (°R)	Total pressure, P_2, (lb/sq ft abs.)	Total pressure, P_2, (lb/sq ft abs.)[a]	Static pressure, p_2, (lb/sq ft abs.)	1	2	3	4	5	6
69	25,000	1.846	0.98	781	483	11,000	746	503	1454	1316	500	1442	1451	1349	1344	1443	1337	1921	2168	2421
70	25,000	1.846	.98	781	480	11,500	970	503	1456	1301	503	1442	1452	1338	1302	1393	1344	1900	2175	2435
71	25,000	1.843	.98	788	477	12,000	1219	504	1466	1297	504	1462	1463	1338	1253	1330	1576	1858	2154	2442
72	25,000	1.836	.98	788	476	12,500	1455	505	1464	1282	505	1447	1458	1325	1189	1246	1365	1788	2104	2407
73	25,000	2.063	1.07	788	519	9,500	152	509	1633	1534	509	1626	1628	1557	1626	1738	1921	2119	2330	2520
74	25,000	2.078	1.08	781	512	10,000	332	506	1631	1516	506	1623	1625	1543	1591	1710	1921	2140	2365	2597
75	25,000	2.074	1.08	781	496	10,500	584	504	1629	1495	504	1620	1622	1526	1555	1675	1900	2154	2407	2661
76	25,000	2.076	1.08	788	508	11,000	826	505	1647	1493	505	1636	1638	1528	1527	1647	1900	2175	2464	2738
77	25,000	2.073	1.08	781	514	11,500	1114	506	1631	1459	506	1619	1623	1499	1457	1555	1816	2189	2435	2731
78	25,000	2.073	1.08	781	517	12,000	1355	506	1632	1445	505	1619	1623	1489	1401	1478	1753	2069	2400	2724
79	25,000	2.054	1.07	781	490	12,500	1617	504	1631	1430	504	1604	1627	1478	1330	1393	1675	1999	2351	2689
80	35,000	1.032	.22	493	440	7,000	100	438	509	499	442	509	509	501	514	542	577	606	627	662
81	35,000	1.041	.24	493	444	8,000	152	440	513	498	441	513	513	501	514	556	599	634	676	718
82	35,000	1.040	.24	500	445	9,000	263	436	521	493	438	520	521	499	514	563	613	676	739	817
83	35,000	1.042	.24	500	444	10,000	386	437	524	484	439	521	523	491	500	549	620	697	782	866
84	35,000	1.048	.26	500	445	11,000	560	437	528	473	439	524	525	485	465	500	592	690	803	908
85	35,000	1.050	.26	500	447	11,500	669	435	530	468	435	525	527	481	437	472	563	677	789	915
86	35,000	1.046	.26	500	444	12,000	762	430	529	463	431	523	527	478	408	444	528	648	775	915
87	35,000	1.046	.26	500	445	12,200	788	429	530	463	431	523	526	477	401	437	521	648	775	929
88	35,000	1.205	.52	493	433	8,000	97	448	595	573	448	594	595	579	599	641	690	739	789	845
89	35,000	1.197	.52	493	441	9,000	200	441	593	560	444	590	590	566	592	641	704	768	845	922
90	35,000	1.200	.52	500	440	10,000	321	450	603	557	451	600	602	568	577	627	711	796	958	993
91	35,000	1.210	.53	500	441	11,000	536	442	608	554	444	605	606	559	535	584	683	789	908	1035
92	35,000	1.210	.53	500	444	11,500	672	440	610	539	440	605	607	554	507	549	648	768	901	1042
93	35,000	1.205	.53	493	430	11,900	714	452	599	527	452	594	598	544	479	514	613	739	873	1021
94	35,000	1.404	.72	500	447	9,000	146	439	705	665	440	702	704	674	711	760	838	922	1000	1105
95	35,000	1.404	.72	500	445	10,000	318	445	705	648	445	702	704	661	683	732	831	944	1049	1162
96	35,000	1.412	.72	500	445	10,500	426	445	711	643	446	706	707	658	648	697	810	929	1056	1183
97	35,000	1.414	.72	500	447	11,000	562	439	712	636	443	707	708	653	627	676	796	922	1056	1204
98	35,000	1.414	.72	500	449	11,500	708	443	712	629	443	707	709	647	592	627	746	887	1042	1197
99	35,000	1.418	.73	493	450	12,000	854	435	706	617	436	699	702	637	542	577	697	852	1014	1190
100	35,000	1.412	.72	493	450	12,000	862	430	705	615	431	696	704	636	542	577	697	845	1014	1190
101	35,000	1.410	.72	500	456	12,450	982	430	714	621	431	705	711	642	521	549	669	838	1028	1232
102	35,000	1.602	.85	500	448	8,000	106	443	805	758	444	801	801	768	803	866	951	1042	1148	1246
103	35,000	1.617	.86	493	443	10,000	345	444	802	735	445	797	799	750	761	824	929	1063	1197	1317
104	35,000	1.615	.86	493	444	10,500	456	447	802	726	448	796	798	743	669	796	915	1063	1204	1338
105	35,000	1.612	.85	500	448	11,000	629	444	812	725	445	806	809	744	718	768	901	1049	1211	1366
106	35,000	1.608	.85	500	452	11,500	801	443	811	715	443	804	807	736	669	718	852	1007	1183	1359
107	35,000	1.615	.85	493	452	12,000	888	445	802	702	450	796	798	726	634	669	803	972	1141	1331
108	35,000	1.618	.85	500	457	12,500	1011	460	819	714	463	809	817	739	620	655	789	965	1155	1359
109	40,000	1.398	.71	394	452	7,000	4	435	552	538	435	551	551	541	549	584	619	647	683	725
110	40,000	1.406	.72	394	460	9,000	119	437	556	524	437	554	554	531	556	598	662	725	788	866
111	40,000	1.406	.77	387	453	10,000	272	442	547	504	441	544	545	513	521	570	647	725	809	901
112	40,000	1.404	.72	394	452	10,500	375	437	556	503	437	553	554	515	514	556	640	732	830	936
113	40,000	1.404	.72	394	454	11,000	466	439	558	498	440	553	555	512	493	528	619	725	830	943
114	40,000	1.411	.72	394	457	11,500	570	441	561	495	443	556	559	511	471	507	598	711	823	950
115	40,000	1.413	.72	387	463	12,000	700	436	552	484	436	547	550	499	429	471	563	683	802	950
116	45,000	1.036	.23	303	452	8,000	102	441	315	306	441	314	315	308	317	336	366	395	416	444
117	45,000	1.041	.24	317	457	9,000	151	444	331	316	444	330	331	319	331	359	394	430	465	507
118	45,000	1.052	.27	310	457	10,000	244	443	324	302	443	326	324	306	310	352	387	437	486	549
119	45,000	1.042	.24	310	457	10,500	310	441	324	297	442	323	324	303	303	338	387	437	493	563
120	45,000	1.042	.24	310	451	11,000	385	435	326	294	436	323	324	300	303	331	380	437	507	578
121	45,000	1.215	.54	303	446	7,500	52	443	369	360	444	368	368	362	366	395	423	444	465	500
122	45,000	1.192	.51	317	441	9,000	140	438	380	359	439	378	378	363	373	416	451	493	535	599
123	45,000	1.210	.53	310	441	9,000	141	435	377	357	436	375	375	361	373	409	437	486	528	585
124	45,000	1.211	.53	303	444	10,000	245	436	368	340	437	367	368	346	345	380	430	493	549	613
125	45,000	1.186	.50	317	444	10,500	320	438	378	343	440	376	377	351	352	387	444	514	577	655
126	45,000	1.192	.51	317	444	10,500	325	437	381	347	438	378	379	354	352	394	444	514	577	655
127	45,000	1.201	.52	303	438	11,000	393	440	366	329	440	364	365	337	324	359	423	493	556	641
128	45,000	1.205	.52	303	442	11,400	466	435	367	327	437	365	365	335	317	345	416	486	563	655
129	45,000	1.416	.72	296	447	7,500	31	441	420	407	441	419	419	410	423	451	479	507	535	571
130	45,000	1.403	.72	310	451	9,000	116	438	438	414	439	435	436	418	437	472	514	563	613	676
131	45,000	1.406	.72	310	454	10,000	234	436	438	403	436	436	437	410	423	458	521	585	655	725
132	45,000	1.405	.72	296	448	10,500	308	434	419	378	434	416	417	387	388	423	486	564	634	718
133	45,000	1.379	.69	317	450	11,000	368	437	441	395	439	437	439	405	394	430	500	577	669	761
134	45,000	1.406	.72	310	452	11,500	488	438	440	390	439	436	438	400	366	402	472	563	655	761
135	45,000	1.397	.71	310	441	12,000	586	425	438	383	425	433	436	395	331	366	444	549	655	789
136	45,000	1.409	.72	303	446	12,100	586	427	433	378	429	427	431	390	324	359	437	542	655	775

[a]Manufacturer's instrumentation.
[b]Data for stage 9 not obtained.
[c]Data not obtained.

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X24C-4B TURBOJET ENGINE WITH 183.1 SQUARE-INCH EXHAUST NOZZLE

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Compressor stator-stage static pressure, p_3 (lb/sq ft abs.)				Compressor outlet					Turbine inlet		Turbine stator-stage static pressure, p_6 (lb/sq ft abs.)		Turbine outlet					Exhaust nozzle outlet		
				Indicated temperature, $T_{1,4}$, (°R)	Indicated temperature, $T_{1,4}$, (°R)[a]	Total pressure, P_4, (lb/sq ft abs.)	Total pressure, P_4, (lb/sq ft abs.)[a]	Static pressure, p_4, (lb/sq ft abs.)	Total pressure, P_5, (lb/sq ft abs.)	Total pressure, P_5, (lb/sq ft abs.)[a]			Indicated temperature, $T_{1,7}$, (°R)	Indicated temperature, $T_{1,7}$, (°R)[a]	Total pressure, P_7, (lb/sq ft abs.)	Total pressure, P_7, (lb/sq ft abs.)[a]	Static pressure, p_7, (lb/sq ft abs.)	Indicated temperature, $T_{1,8}$, (°R)	Total pressure, P_8, (lb/sq ft abs.)	Static pressure, p_8, (lb/sq ft abs.)
7	8	[b]10	11								1	2								
2675	2970	3674	3646	721	730	4309	4336	4177	3986	3991	3477	2257	1072	1192	1862	1851	1527	1058	1822	1173
2689	3076	3949	4083	742	751	4727	4737	4580	4378	4393	3831	2494	1170	1299	2050	2041	1684	1168	2003	1293
2759	3160	4245	4505	764	772	5134	5132	4960	4775	4786	4162	2717	1294	1423	2240	2231	1837	1286	2195	1412
2766	3224	4512	4899	786	792	5523	5512	5292	5146	5150	4491	2924	1411	1529	2412	2428	1992	1397	2362	1520
2717	2900	3210	2801	661	668	3416	3414	3271	3081	3090	2696	1743	795	851	1487	1457	1212	782	1429	976
2801	3034	3463	3196	679	686	3807	3822	3671	3472	3481	3034	1959	878	980	1654	1626	1342	859	1596	1053
2914	3182	4273	3703	679	705	4290	4329	4166	3951	3963	3451	2229	977	1073	1681	1837	1520	961	1815	1172
3034	3351	4111	4160	719	728	4793	4822	4650	4426	4432	3874	2503	1065	1187	2112	2062	1705	1059	2029	1303
3062	3442	4407	4646	743	753	5278	5280	5101	4878	4889	4273	2759	1178	1315	2337	2281	1886	1188	2247	1450
3083	3470	4674	5075	762	771	5666	5660	5475	5263	5273	4604	2985	1280	1376	2542	2464	2034	1289	2424	1555
3083	3583	5005	5336	785	791	6120	6110	5872	5699	5709	4970	3247	1400	1548	2688	2689	2210	1385	2620	1684
697	746	803	803	541	545	864	866	850	824	824	741	585	1160	1340	560	556	528	1140	555	507
768	831	922	929	570	577	1018	1021	998	962	965	857	632	1133	1293	593	585	540	1139	588	509
887	979	1134	1162	602	611	1287	1296	1257	1204	1204	1063	732	1052	1236	656	662	577	1089	652	530
965	1084	1338	1415	636	647	1565	1570	1523	1454	1464	1283	847	1095	1250	738	732	627	1121	729	553
1035	1190	1584	1732	678	685	1888	1887	1822	1764	1767	1549	1007	1268	1394	854	859	718	1271	839	588
1063	1253	1753	1901	701	704	2080	2070	1985	1943	1943	1702	1106	1374	1497	933	936	775	1386	912	619
1084	1324	1880	1978	716	719	2215	2204	2101	2077	2077	1816	1181	1498	1599	989	993	815	1481	970	651
1112	1359	1922	2007	722	726	2265	2246	2140	2119	2119	1857	1206	1534	1615	1011	1014	836	1509	990	658
901	965	1049	1000	566	572	1129	1134	1099	1049	1053	932	664	917	1056	624	613	556	909	614	516
1000	1091	1246	1232	596	604	1390	1401	1357	1293	1296	1139	768	963	1110	697	683	597	950	672	533
1091	1211	1464	1500	641	653	1701	1704	1652	1577	1577	1385	908	1047	1205	794	782	662	1062	770	567
1169	1331	1767	1915	678	687	2110	2112	2041	1975	1978	1730	1120	1198	1330	979	936	784	1223	929	626
1197	1408	1950	2119	700	704	2337	2323	2238	2183	2187	1917	1239	1319	1456	1058	1042	857	1348	1014	668
1190	1415	1985	2176	726	729	2380	2366	2263	2220	2218	1948	1253	1432	1549	1072	1056	866	1442	1032	681
1190	1281	1443	1366	584	592	1578	1591	1531	1455	1457	1279	845	870	980	744	732	634	812	725	554
1281	1408	1697	1725	630	639	1962	1971	1908	1818	1820	1591	1035	955	1100	875	866	730	955	859	599
1317	1479	1859	2584	653	662	2206	2211	2135	2037	2042	1788	1153	1027	1158	967	965	801	1043	951	638
1358	1542	2035	2204	669	676	2438	2443	2354	2276	2274	1988	1284	1127	1271	1052	1070	885	1145	1050	689
1373	1591	2204	2281	693	698	2625	2654	2560	2483	2492	2178	1403	1234	1378	1167	1169	963	1259	1147	742
1401	1685	2415	2640	713	716	2894	2873	2739	2690	2704	2359	1523	1421	1484	1269	1274	1047	1417	1240	798
1401	1690	2429	2598	707	709	2908	2887	2748	2711	2711	2366	1535	1397	1531	1284	1281	1051	1388	1244	803
1500	1852	2640	2725	732	737	3109	3077	2927	2906	2901	2537	1652	1552	1673	1377	1380	1129	1535	1337	862
1345	1443	1619	1493	584	591	1750	1760	1688	1596	1602	1401	910	777	892	790	789	669	743	768	767
1450	1598	1936	1950	629	637	2231	2253	2168	2072	2063	1802	1164	934	1061	972	965	808	920	952	634
1493	1655	2077	2154	650	658	2438	2464	2377	2267	2274	1981	1279	997	1122	1066	1056	880	1010	1044	682
1535	1746	2288	2471	669	677	2748	2753	2661	2565	2563	2237	1445	1113	1249	1202	1211	991	1133	1177	759
1556	1809	2506	2760	695	700	3089	3027	2913	2828	2837	2478	1614	1255	1385	1332	1345	1103	1267	1306	838
1549	1838	2640	2894	717	719	3179	3147	3022	2957	2964	2593	1669	1363	1466	1386	1394	1146	1371	1366	873
1605	1957	2837	3013	759	762	3304	3358	3201	3165	3161	2765	1795	1545	1645	1498	1500	1230	1521	1458	936
760	795	816	739	517	520	831	838	803	767	767	690	509	812	870	481	478	443	776	478	408
936	1014	1147	1105	586	593	1265	1274	1230	1168	1168	1028	677	855	1001	593	591	507	816	579	438
992	1098	1323	1359	631	639	1536	1542	1493	1426	1426	1245	804	953	1113	677	669	565	978	667	461
1042	1175	1485	1577	647	656	1761	1767	1710	1637	1640	1434	924	1053	1178	775	774	642	1078	761	507
1063	1218	1612	1746	671	678	1926	1929	1862	1799	1802	1575	1014	1158	1275	848	845	699	1175	833	542
1098	1281	1767	1929	699	702	2127	2119	2039	1985	1985	1741	1124	1317	1416	937	943	772	1324	916	592
1126	1344	1922	2084	715	718	2280	2267	2161	2130	2126	1863	1201	1470	1542	1003	1007	828	1457	981	629
479	521	585	592	575	584	644	648	634	611	613	544	400	1225	1316	373	373	338	1150	367	317
549	606	704	725	606	619	801	803	783	753	750	667	463	1246	1273	424	423	366	1158	414	340
606	683	845	901	649	659	985	993	960	926	926	815	544	1297	1330	477	479	404	1218	463	347
634	725	930	1007	673	682	1091	1091	1058	1025	1028	906	597	1393	1413	512	514	425	1285	504	354
662	775	1028	1113	690	693	1213	1211	1167	1141	1138	1000	689	1519	1462	562	563	467	1406	545	375
528	563	599	578	551	558	643	648	627	604	599	540	397	1066	1109	377	373	338	1010	368	317
641	711	817	824	601	609	921	922	899	859	859	758	507	1085	1142	460	444	387	1025	443	347
634	697	803	803	593	603	895	901	874	835	831	737	498	1009	1136	448	444	378	962	436	340
683	768	951	1000	638	650	1111	1113	1080	1035	1035	910	594	1143	1226	512	507	418	1124	501	354
732	838	1070	1155	666	673	1261	1267	1226	1185	1183	1037	676	1294	1314	585	570	474	1215	561	388
732	838	1077	1162	666	675	1265	1267	1227	1188	1183	1042	681	1250	1367	590	585	481	1186	566	388
732	852	1134	1225	687	694	1341	1338	1291	1257	1257	1101	718	1387	1456	618	606	502	1326	594	396
761	901	1225	1331	709	714	1446	1443	1379	1354	1352	1190	777	1553	1597	659	655	537	1440	640	420
599	641	669	620	543	548	698	697	676	645	645	576	409	874	960	378	373	338	885	372	318
732	796	894	880	591	597	995	1007	970	922	922	812	535	937	997	467	465	397	881	459	347
803	894	1091	1120	625	636	1268	1274	1232	1176	1176	1030	669	1016	1118	562	563	470	1005	552	377
803	916	1155	1246	651	661	1374	1380	1332	1280	1282	1122	723	1072	1200	604	599	498	1104	591	392
859	993	1296	1415	674	687	1566	1549	1495	1447	1447	1269	822	1207	1297	689	683	563	1207	667	438
873	1035	1429	1556	705	707	1716	1697	1625	1591	1591	1392	901	1390	1464	758	761	620	1376	737	476
922	1127	1584	1662	711	715	1870	1859	1769	1748	1746	1530	991	1508	1598	826	831	676	1479	808	519
937	1141	1584	1655	723	729	1865	1859	1769	1746	1746	1530	995	1539	1638	831	831	678	1514	808	519

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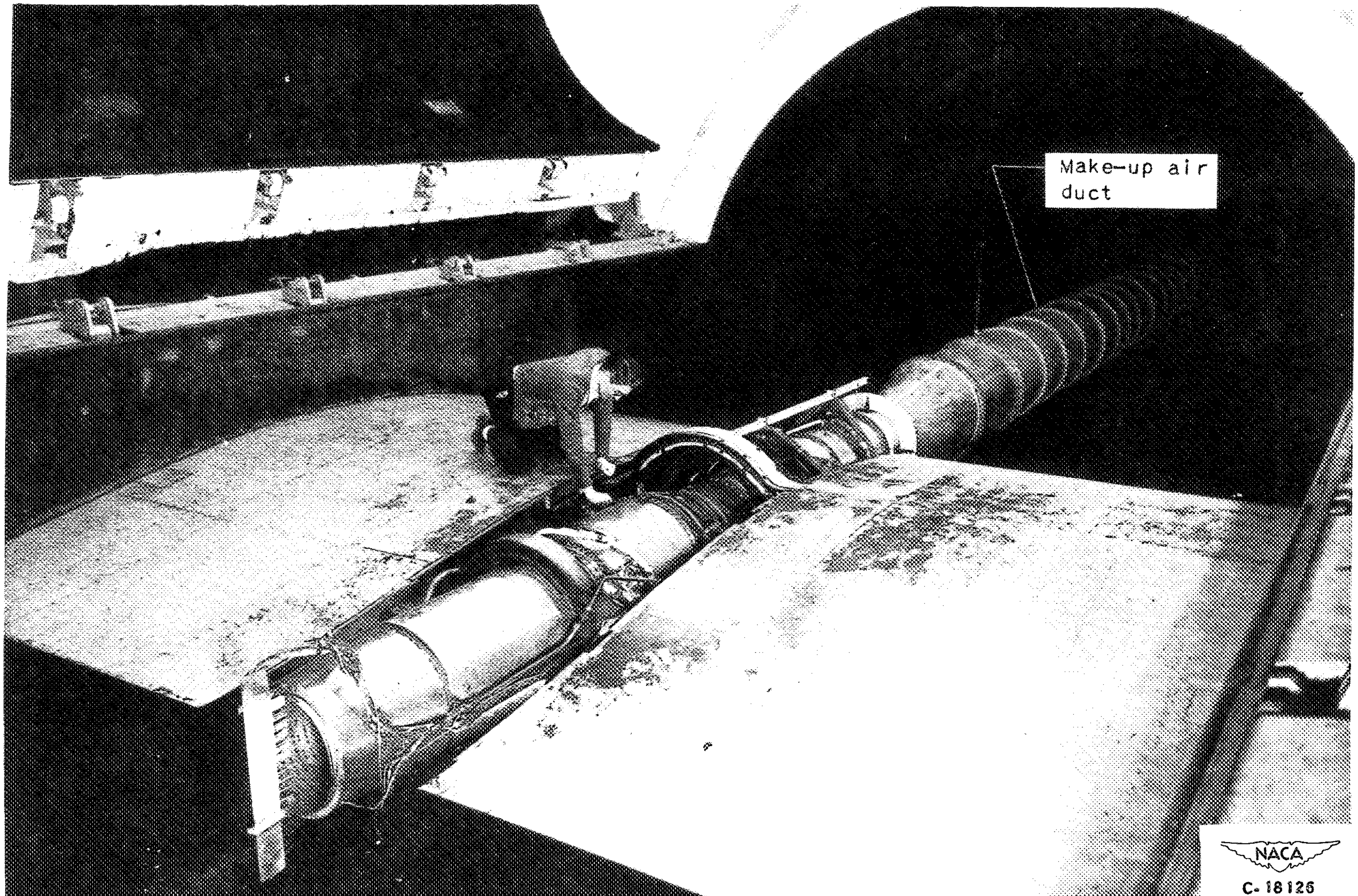

Figure 1. - Installation of X24C-4B turbojet engine in altitude wind tunnel.

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Figure 9. - Instrumentation at turbine inlet, station 5, $2\frac{3}{4}$ inches in front of center line of first-stage turbine stator blade.
(a) Location of total-pressure tubes.
(b) Detail sketch of total-pressure-tube installation.

Figure 10. - Instrumentation at turbine inlet, station 5, $2\frac{3}{16}$ inches in front of center line of first-stage turbine stator blade.
(a) Location of manufacturer's instrumentation.
(b) Detail sketch of manufacturer's total-pressure tube.

Figure 11. - Location of static-pressure tubes at turbine stator stages, station 6, center line of each stator blade.

Figure 12. - Instrumentation at turbine outlet, station 7, $3\frac{3}{4}$ inches behind rear flange of turbine casing.
(a) Location of instrumentation.
(b) Detail sketch of total-pressure-tube and thermocouple installation.
(c) Detail sketch of thermocouple rake.
(d) Detail sketch of single-thermocouple installation.

Figure 13. - Instrumentation at turbine outlet, station 7, $2\frac{5}{8}$ inches behind rear flange of turbine casing.
(a) Location of manufacturer's instrumentation.
(b) Detail sketch of manufacturer's total-pressure integrating rake.
(c) Detail sketch of manufacturer's thermocouple installation.

Figure 14. - Instrumentation in exhaust-nozzle outlet, station 8, 1 inch in front of rear edge of exhaust-nozzle outlet.
(a) Location of instrumentation.
(b) Detail sketch of pressure and temperature survey rake.

Figure 15. - Variation of average total and static pressures through engine for several altitudes. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

Figure 16. - Effect of altitude on corrected total-pressure, static-pressure, and indicated-temperature distribution at cowl inlet, station 1. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

Figure 17. - Effect of altitude on radial and circumferential distribution of corrected total pressure, static pressure, and indicated temperature at compressor inlet, station 2. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

Figure 18. - Effect of altitude on radial distribution of corrected total pressure, static pressure, and indicated temperature at compressor outlet, station 4. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

Figure 19. - Effect of altitude on circumferential distribution of corrected total pressure at turbine inlet, station 5. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

Figure 20. - Effect of altitude on radial distribution of corrected total pressure at turbine outlet, station 7. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

Figure 21. - Effect of altitude on corrected indicated temperature at turbine outlet, station 7. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.
(a) Radial distribution.
(b) Circumferential distribution.

Figure 22. - Effect of altitude on corrected total-pressure, static-pressure, and indicated-temperature distribution at exhaust-nozzle outlet, station 8. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

Figure 23. - Variation of average total and static pressures through engine with Mach number. Altitude, 25,000 feet; engine speed, 12,000 rpm.

Figure 24. - Effect of Mach number on total-pressure, static-pressure, and indicated-temperature distribution at cowl inlet, station 1. Altitude, 25,000 feet; engine speed, 12,000 rpm.

Figure 25. - Effect of Mach number on radial and circumferential distribution of total pressure, static pressure, and indicated temperature at compressor inlet, station 2. Altitude, 25,000 feet; engine speed, 12,000 rpm.

Figure 26. - Effect of Mach number on radial distribution of total pressure, static pressure, and indicated temperature at compressor outlet, station 4. Altitude, 25,000 feet; engine speed, 12,000 rpm.

Figure 27. - Effect of Mach number on circumferential distribution of total pressure at turbine inlet, station 5. Altitude, 25,000 feet; engine speed, 12,000 rpm.

Figure 28. - Effect of Mach number on radial distribution of total pressure at turbine outlet, station 7. Altitude, 25,000 feet; engine speed, 12,000 rpm.

Figure 29. - Effect of Mach number on indicated temperature at turbine outlet, station 7. Altitude, 25,000 feet; engine speed, 12,000 rpm.
(a) Radial distribution.
(b) Circumferential distribution.

Figure 30. - Effect of Mach number on total pressure, static pressure, and indicated temperature at exhaust-nozzle outlet, station 8. Altitude, 25,000 feet; engine speed, 12,000 rpm.

Figure 31. - Variation of average total and static pressures through engine with engine speed. Mach number, approximately 0.53; altitude, 25,000 feet.

Figure 32. - Effect of engine speed on total-pressure, static-pressure, and indicated-temperature distribution at cowl inlet, station 1. Mach number, approximately 0.53; altitude, 25,000 feet.

Figure 33. - Effect of engine speed on radial and circumferential distribution of total pressure, static pressure, and indicated temperature at compressor inlet, station 2. Mach number, approximately 0.53; altitude, 25,000 feet.

Figure 34. - Effect of engine speed on radial distribution of total pressure, static pressure, and indicated temperature at compressor outlet, station 4. Mach number, approximately 0.53; altitude, 25,000 feet.

Figure 35. - Effect of engine speed on circumferential distribution of total pressure at turbine inlet, station 5. Mach number, approximately 0.53; altitude, 25,000 feet.

Figure 36. - Effect of engine speed on radial and circumferential distribution of total pressure at turbine outlet, station 7. Mach number, approximately 0.53; altitude, 25,000 feet.

Figure 37. - Effect of engine speed on indicated temperature at turbine outlet, station 7. Mach number, approximately 0.53; altitude, 25,000 feet.
(a) Radial distribution.
(b) Circumferential distribution.

Figure 38. - Effect of engine speed on total pressure, static pressure, and indicated temperature at exhaust-nozzle outlet, station 8. Mach number, approximately, 0.53; altitude, 25,000 feet.

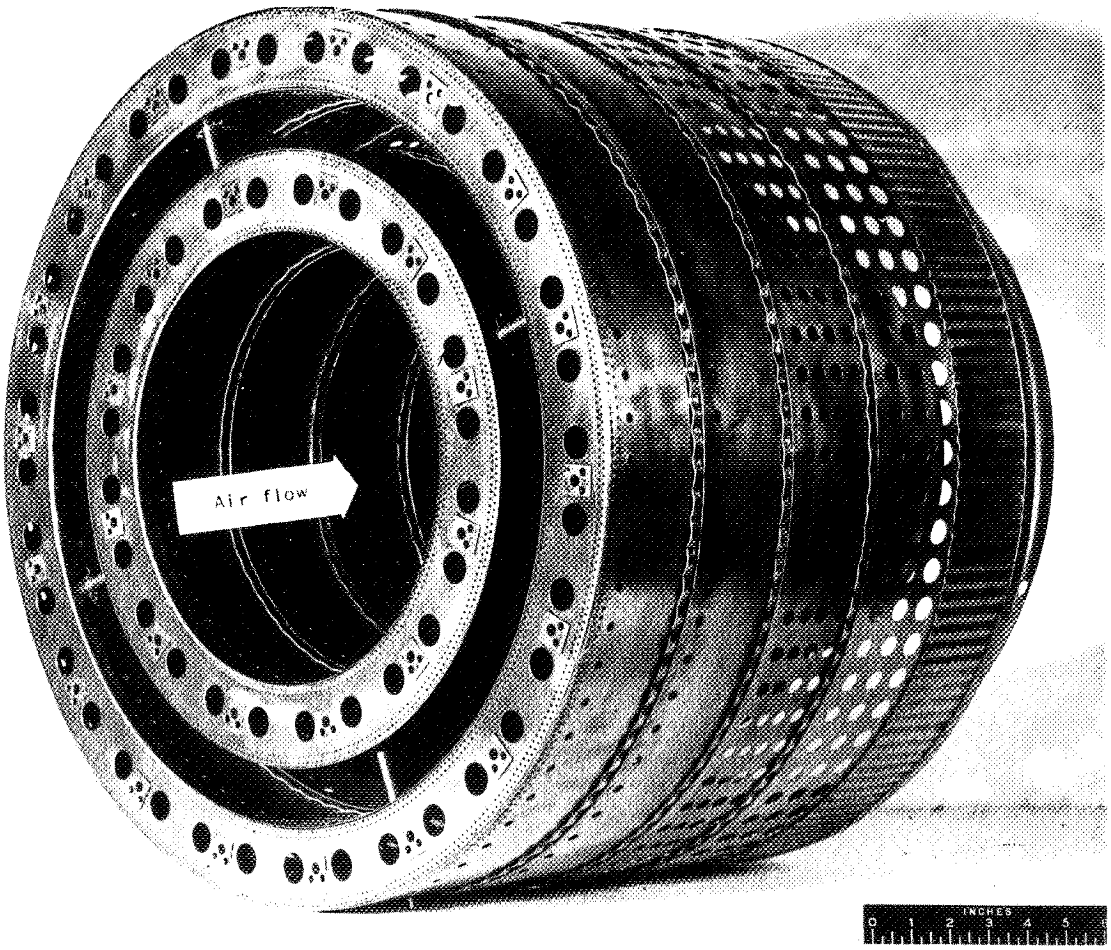

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Figure 2. - Double-annulus combustion chamber of X24C-4B turbojet engine.

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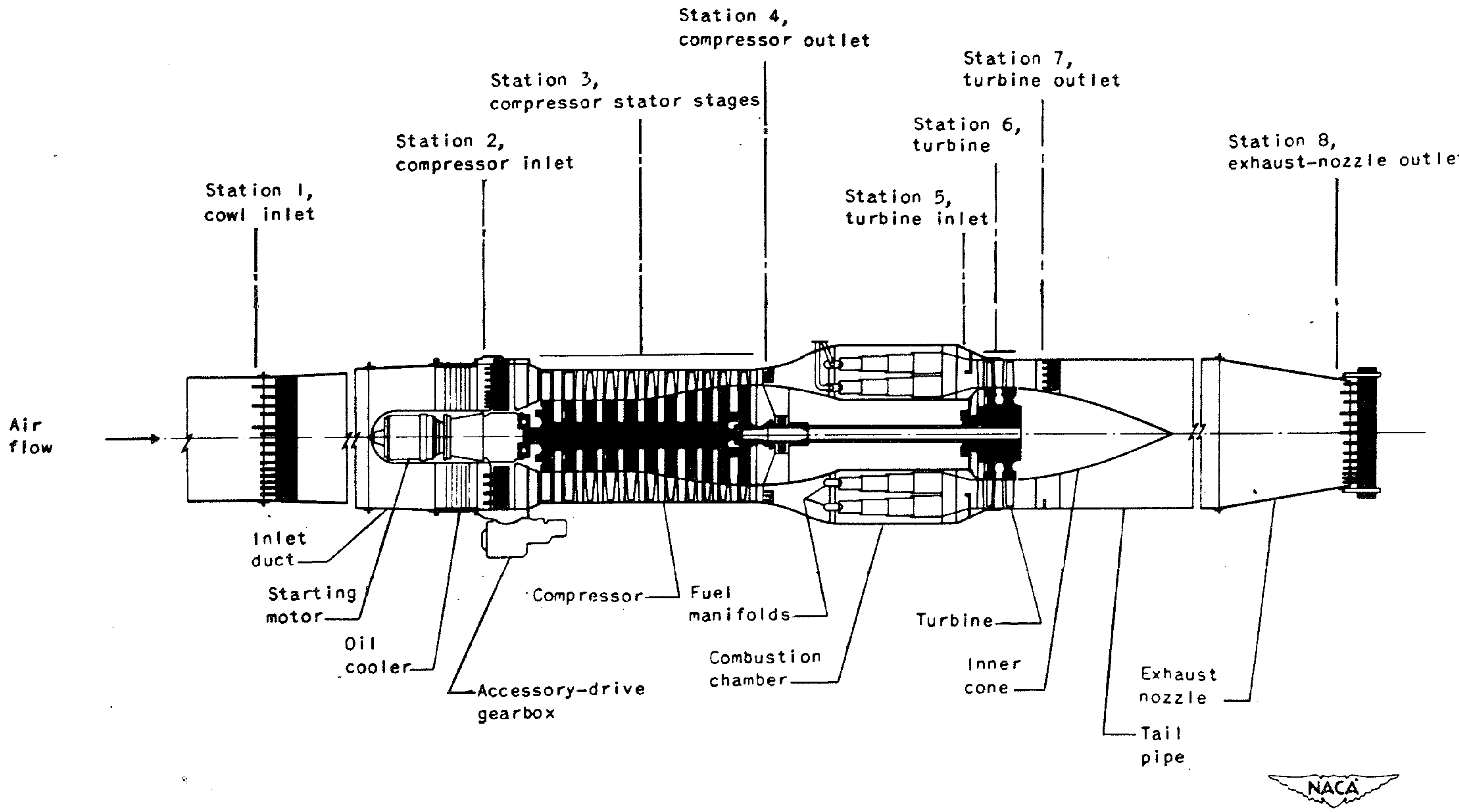

Figure 3. - Sectional side view of X24C-4B turbojet engine showing stations at which instrumentation was installed.

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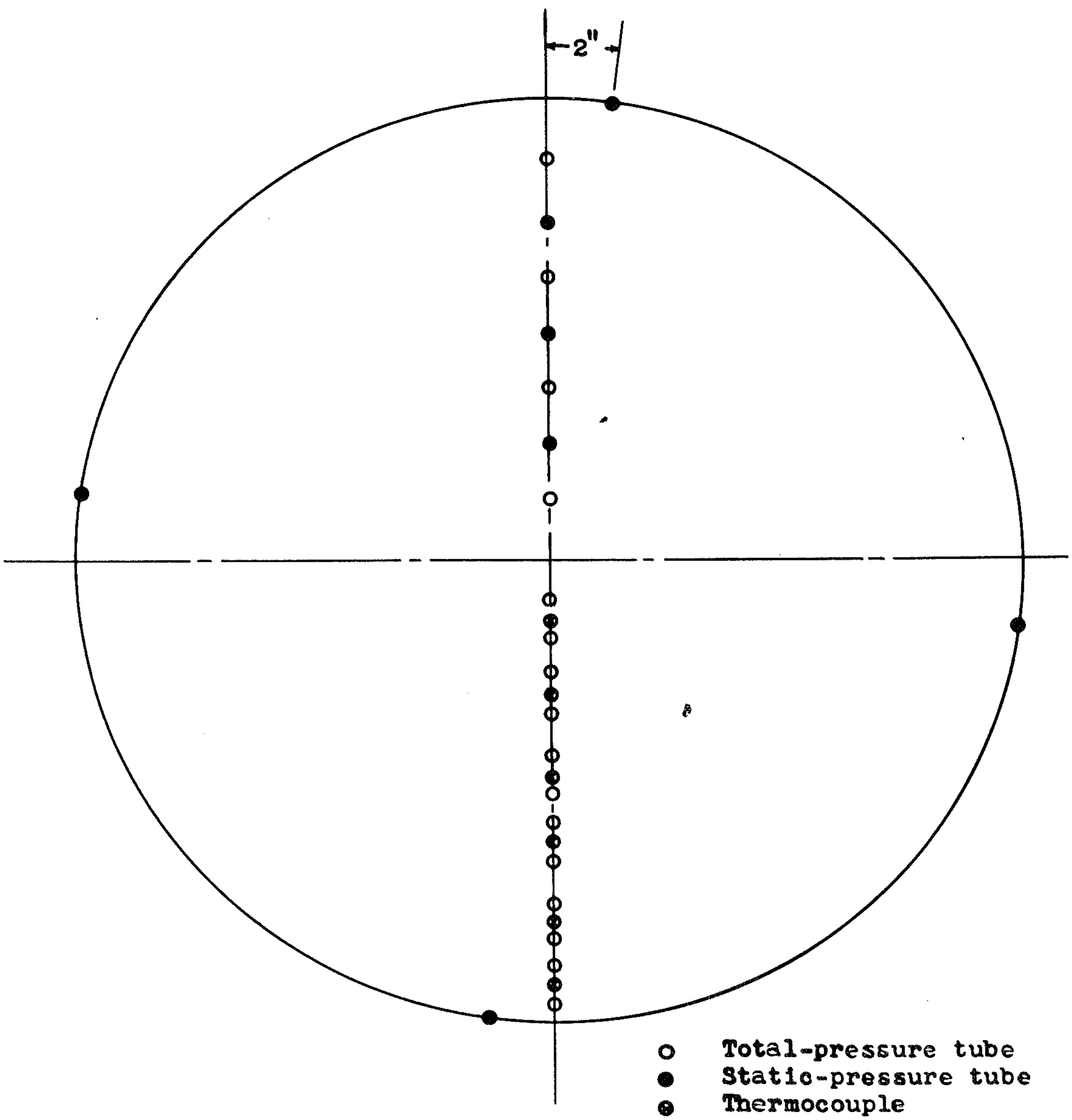
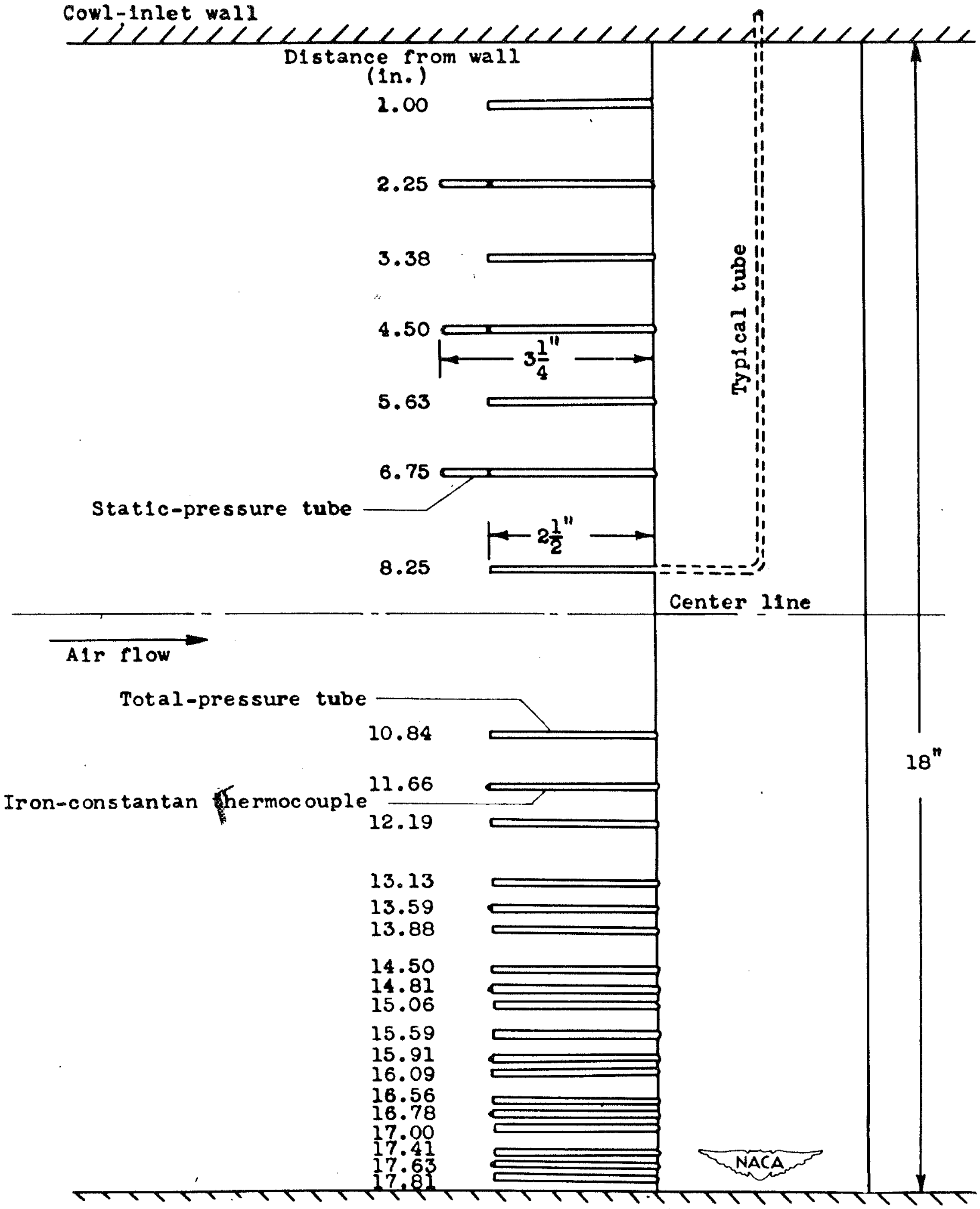


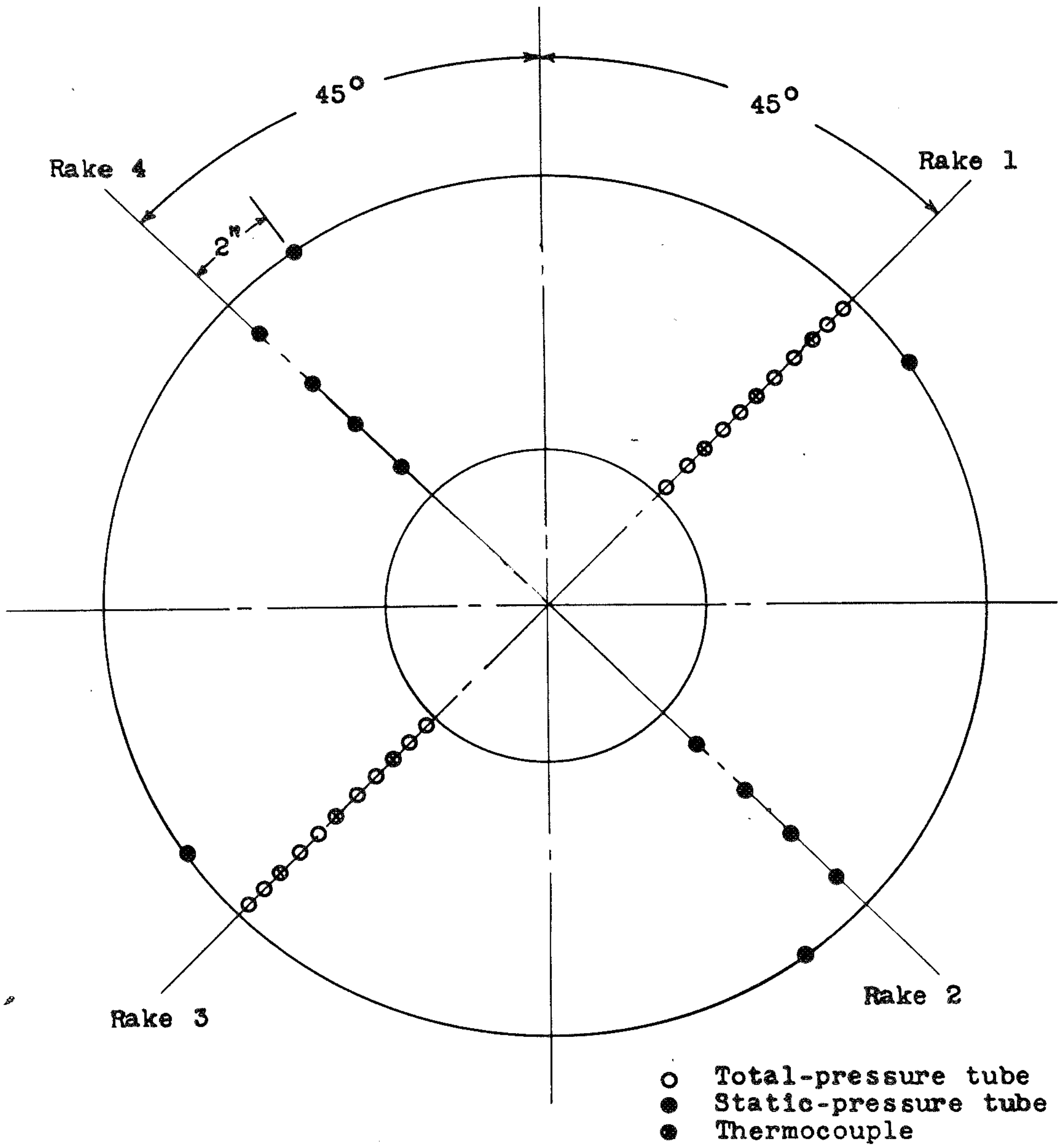
(a) Location of instrumentation.

Figure 4. - Instrumentation at cowl inlet, station 1, $4\frac{5}{8}$ inches in front of front flange of oil cooler.



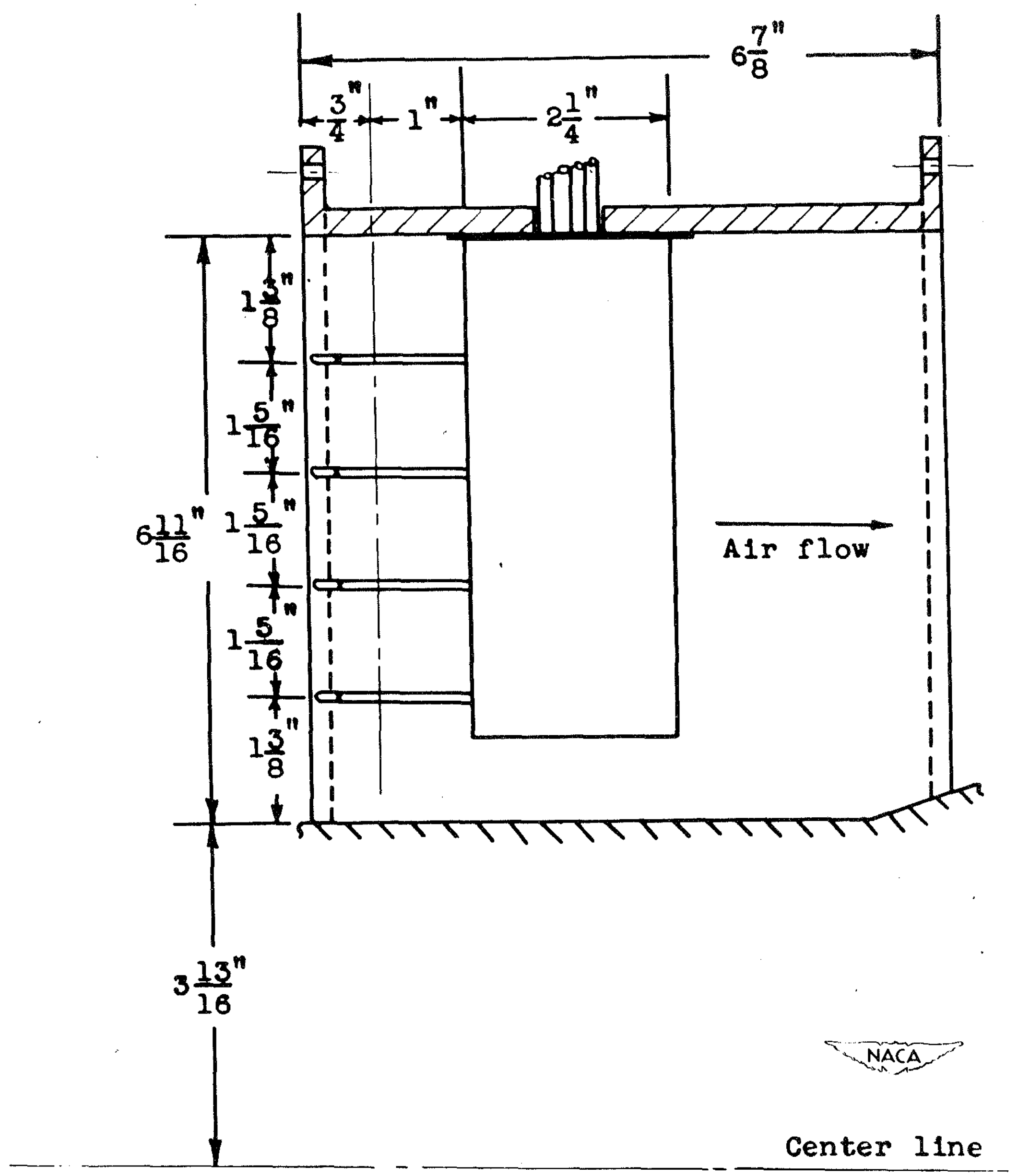
(b) Detail sketch of pressure and temperature survey rake.

Figure 4. - Concluded. Instrumentation at cowl inlet, station 1, $41\frac{5}{8}$ inches in front of front flange of oil cooler.



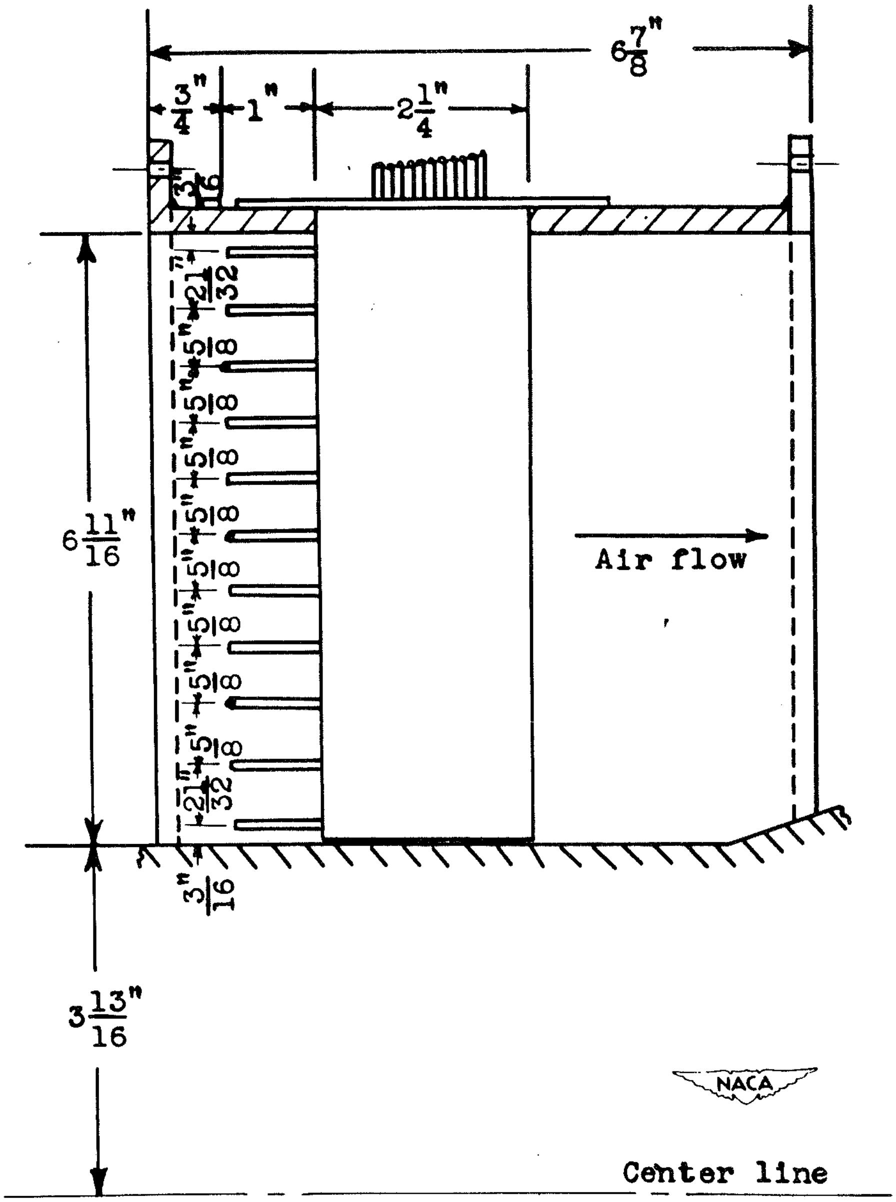
(a) Location of instrumentation.

Figure 5. - Instrumentation at compressor inlet, station 2, $\frac{3}{4}$ inch behind rear flange of oil cooler.



(b) Detail sketch of static-pressure-tube installation.

Figure 5. - Continued. Instrumentation at compressor inlet, station 2, $\frac{3}{4}$ inch behind rear flange of oil cooler.



(c) Detail sketch of total-pressure-tube and thermocouple installation.

Figure 5. - Concluded. Instrumentation at compressor inlet, station 2, $\frac{3}{4}$ inch behind rear flange of oil cooler.

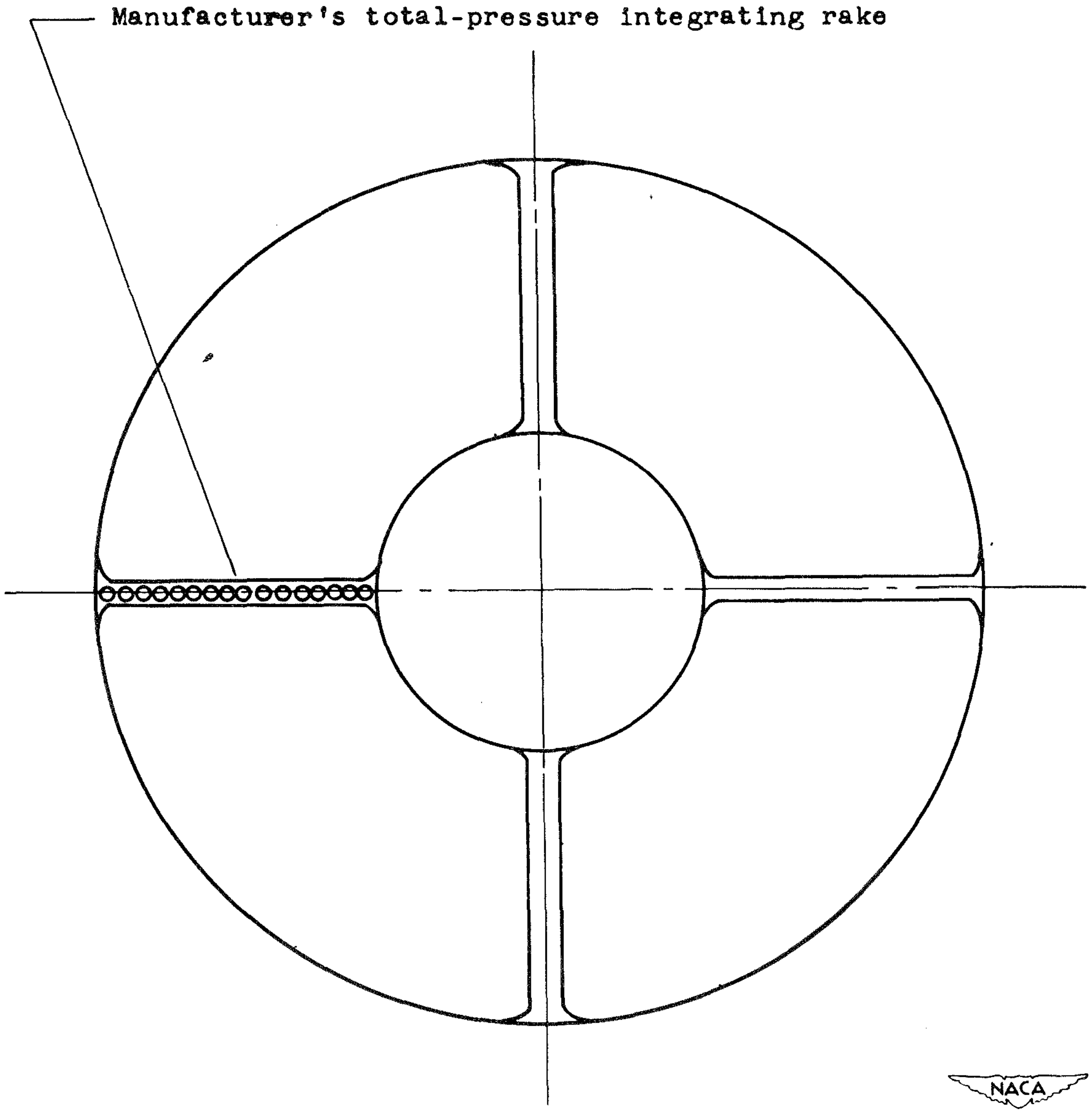
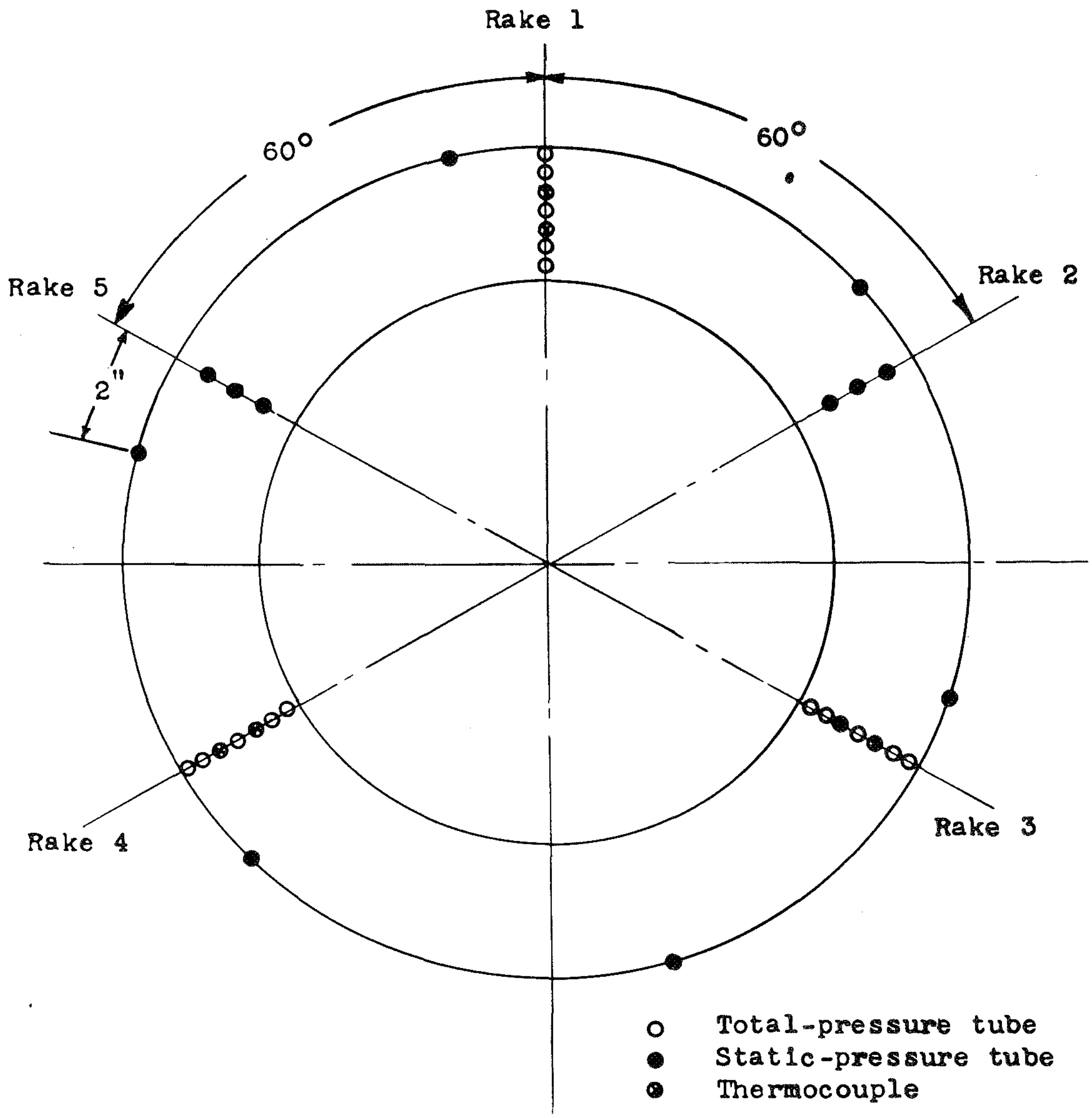
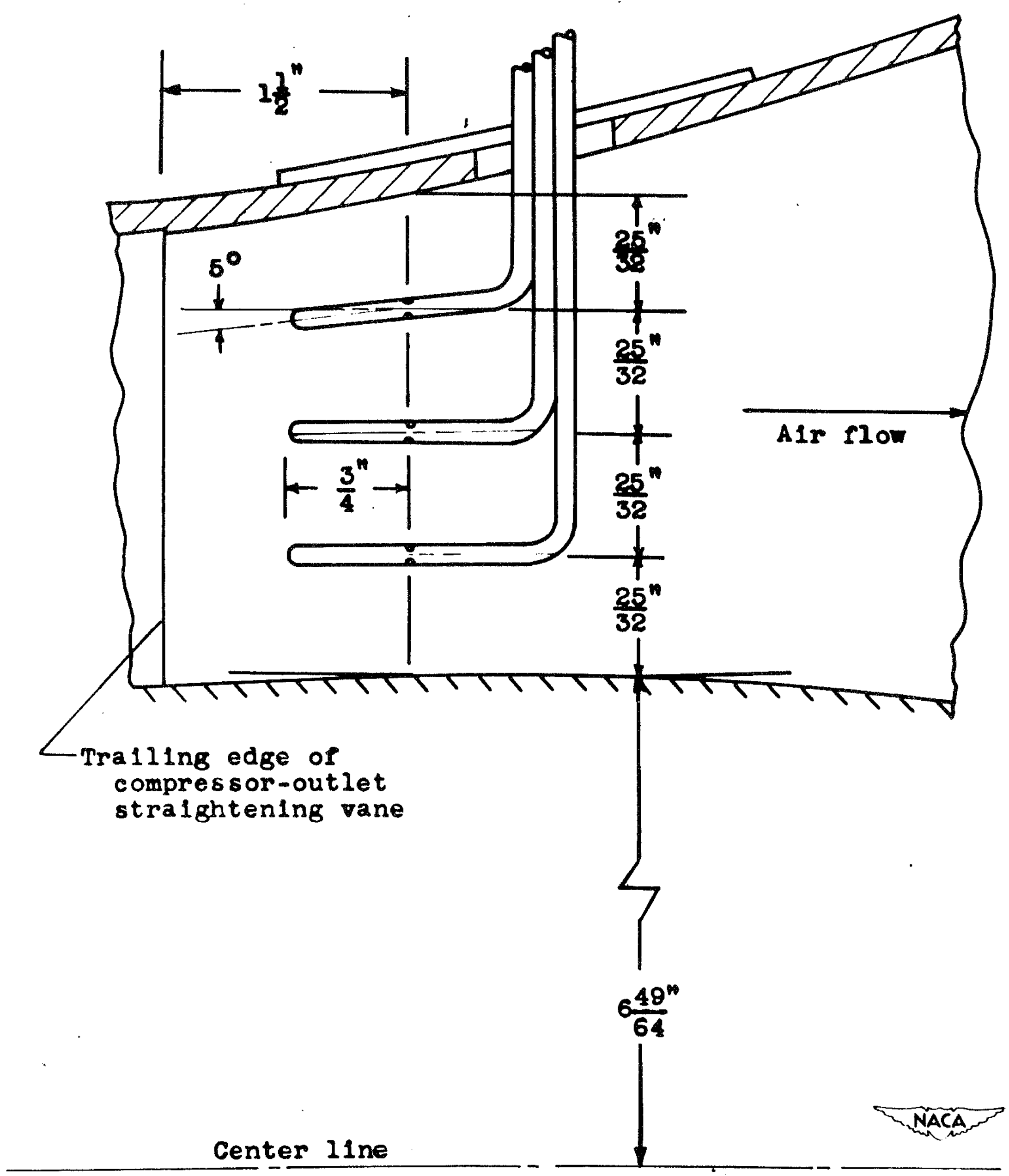


Figure 6. - Location of manufacturer's total-pressure integrating rake at compressor inlet, station 2, $1\frac{3}{4}$ inches behind rear flange of oil cooler.



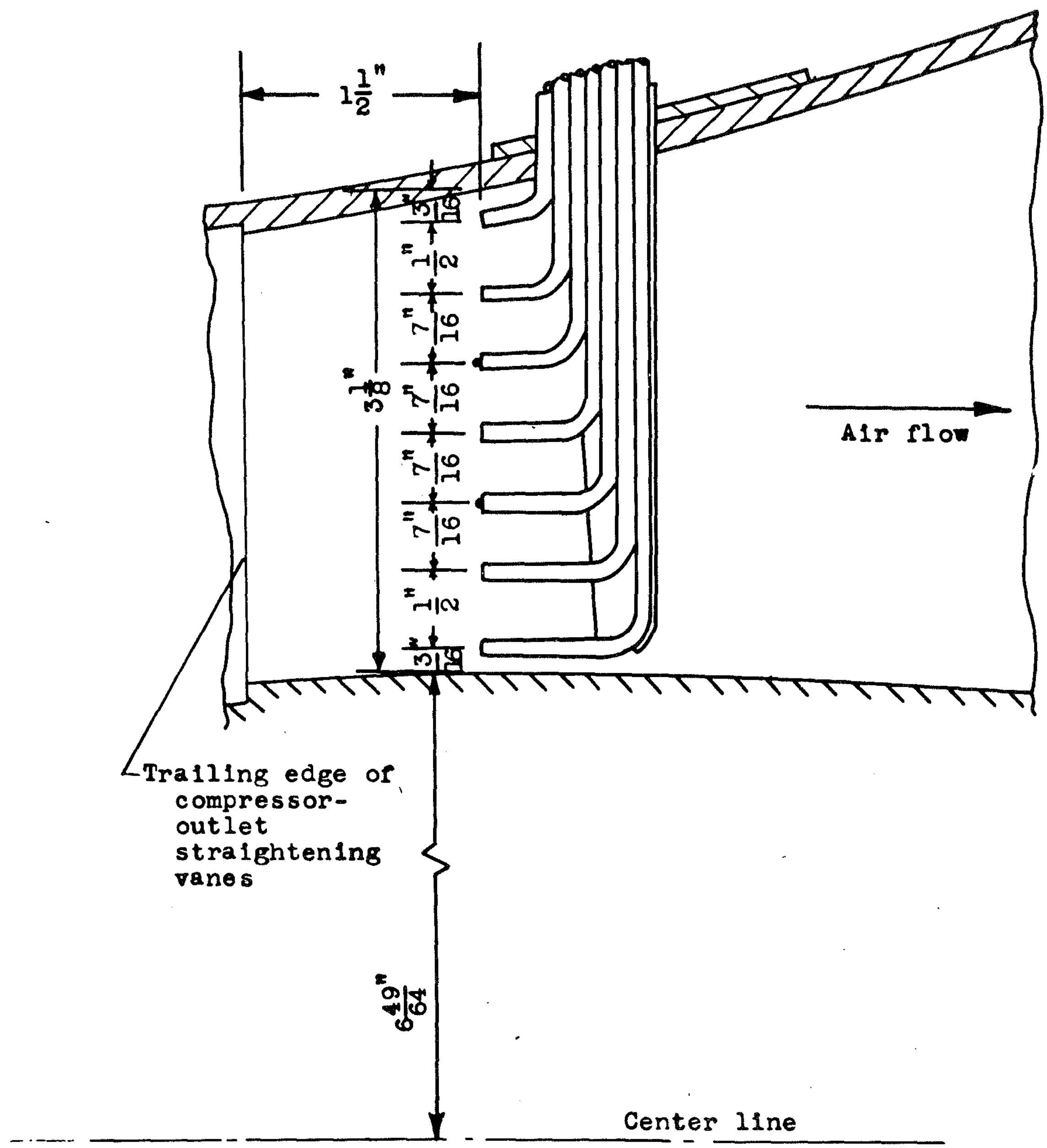
(a) Location of instrumentation.

Figure 7. - Instrumentation at compressor outlet, station 4, $1\frac{1}{2}$ inches behind trailing edge of compressor-outlet straightening vanes.



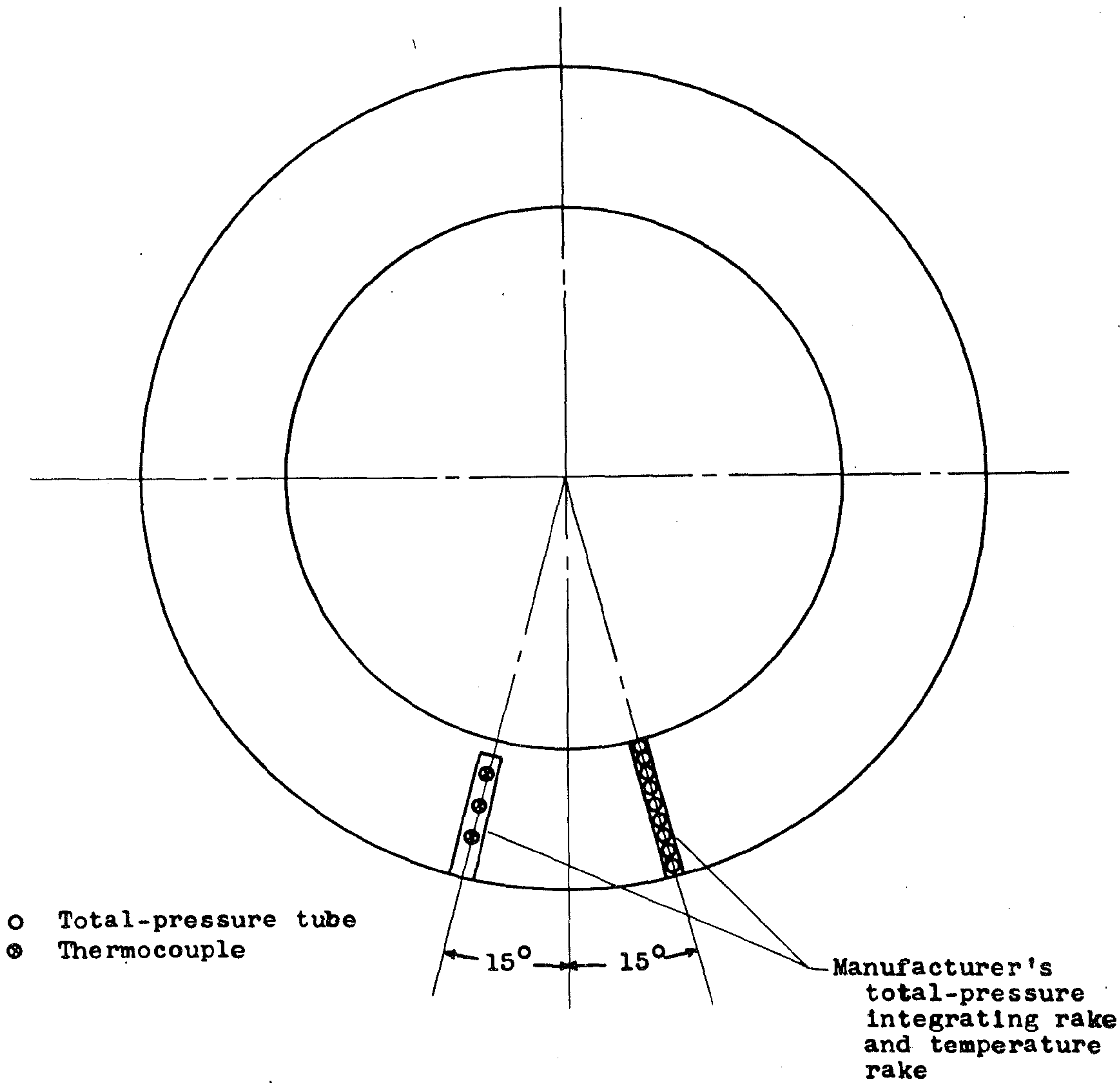
(b) Detail sketch of static-pressure-tube installation.

Figure 7. - Continued. Instrumentation at compressor outlet, station 4, $1\frac{1}{2}$ inches behind trailing edge of compressor-outlet straightening vanes.



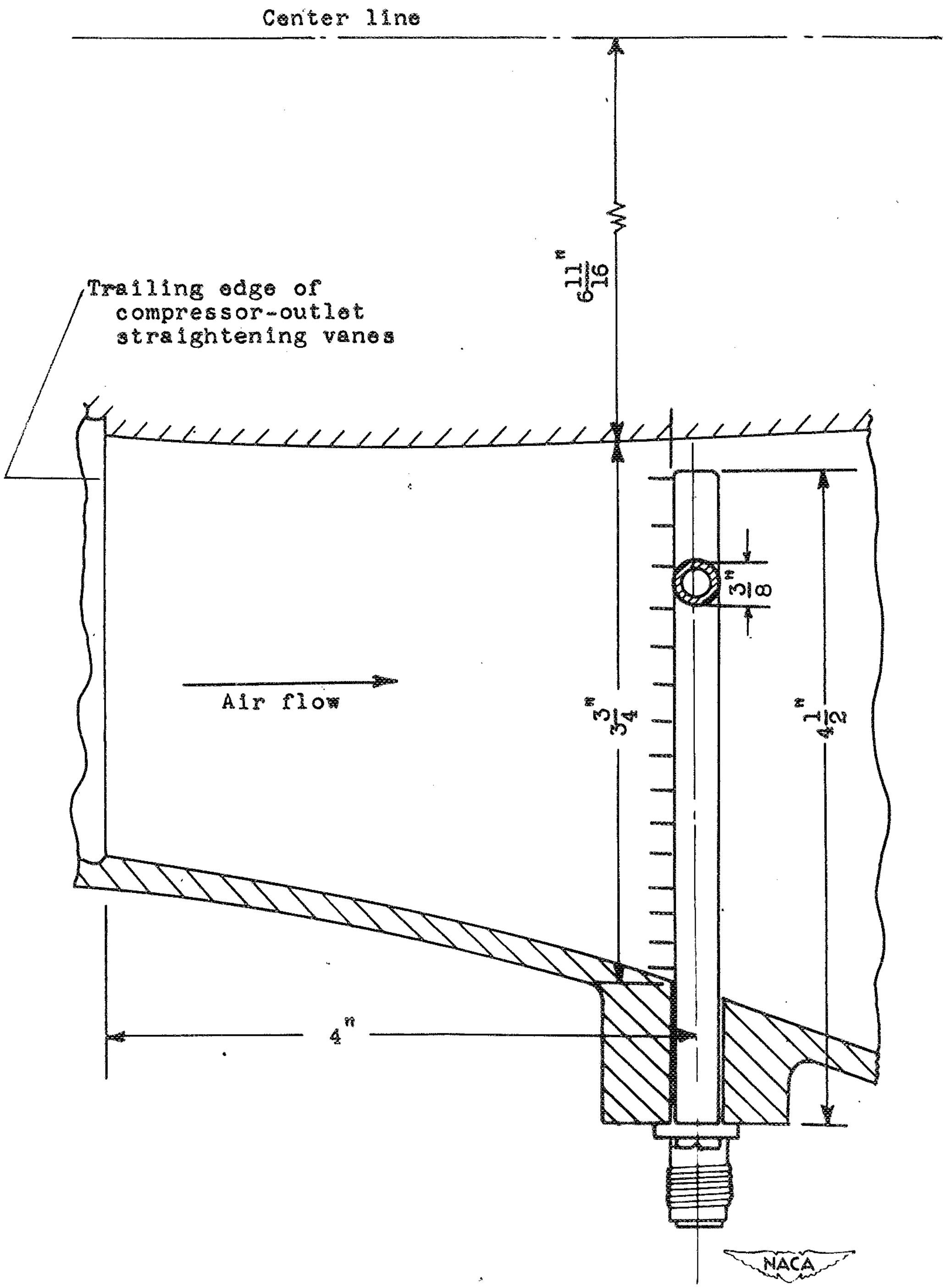
(c) Detail sketch of total-pressure-tube and thermocouple installation.

Figure 7. - Concluded. Instrumentation at compressor outlet, station 4, $1\frac{1}{2}$ inches behind trailing edge of compressor-outlet straightening vanes.



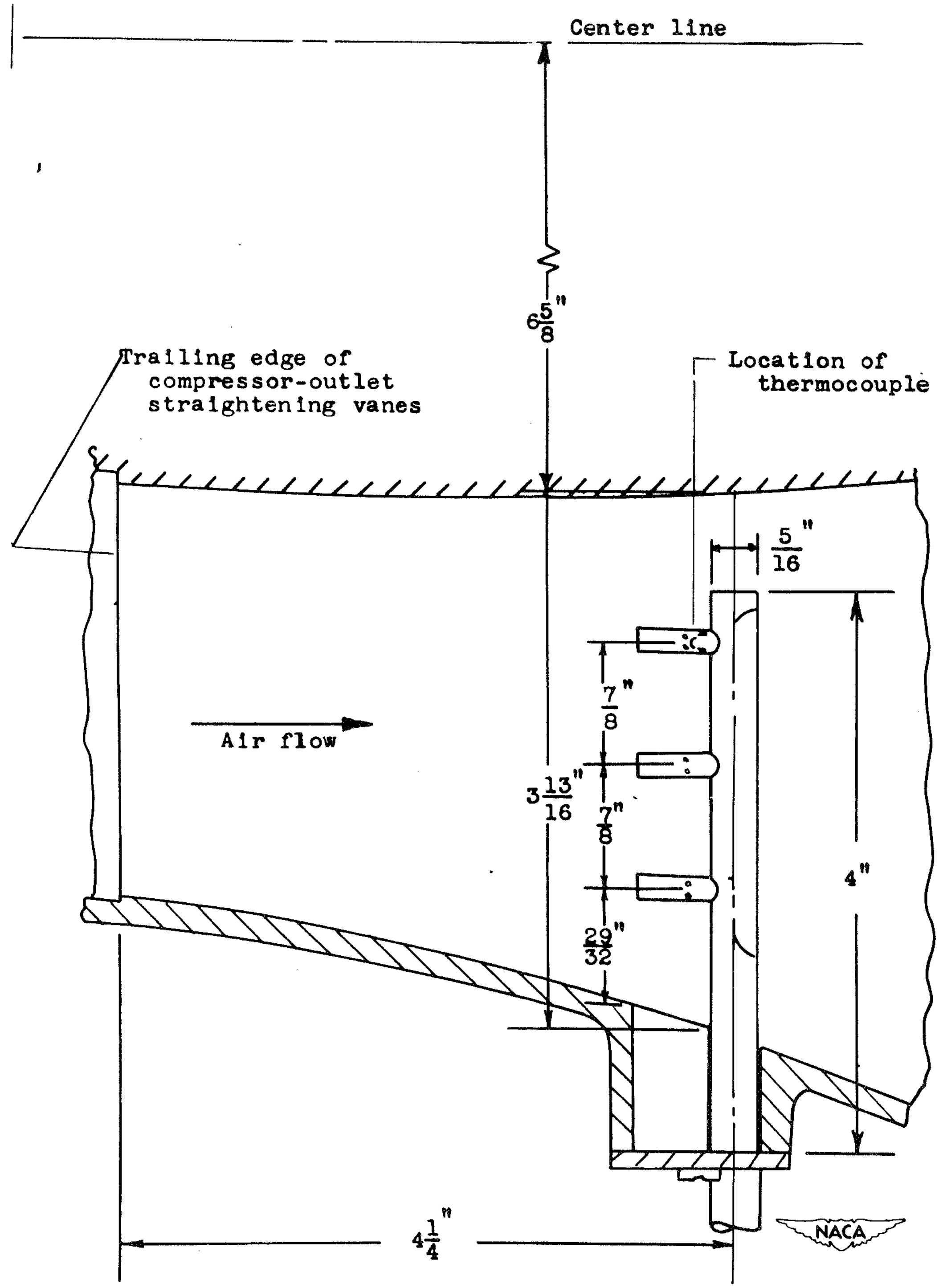
(a) Location of manufacturer's instrumentation.

Figure 8. - Instrumentation at compressor outlet, station 4, $3\frac{13}{16}$ inches behind trailing edge of compressor-outlet straightening vanes.



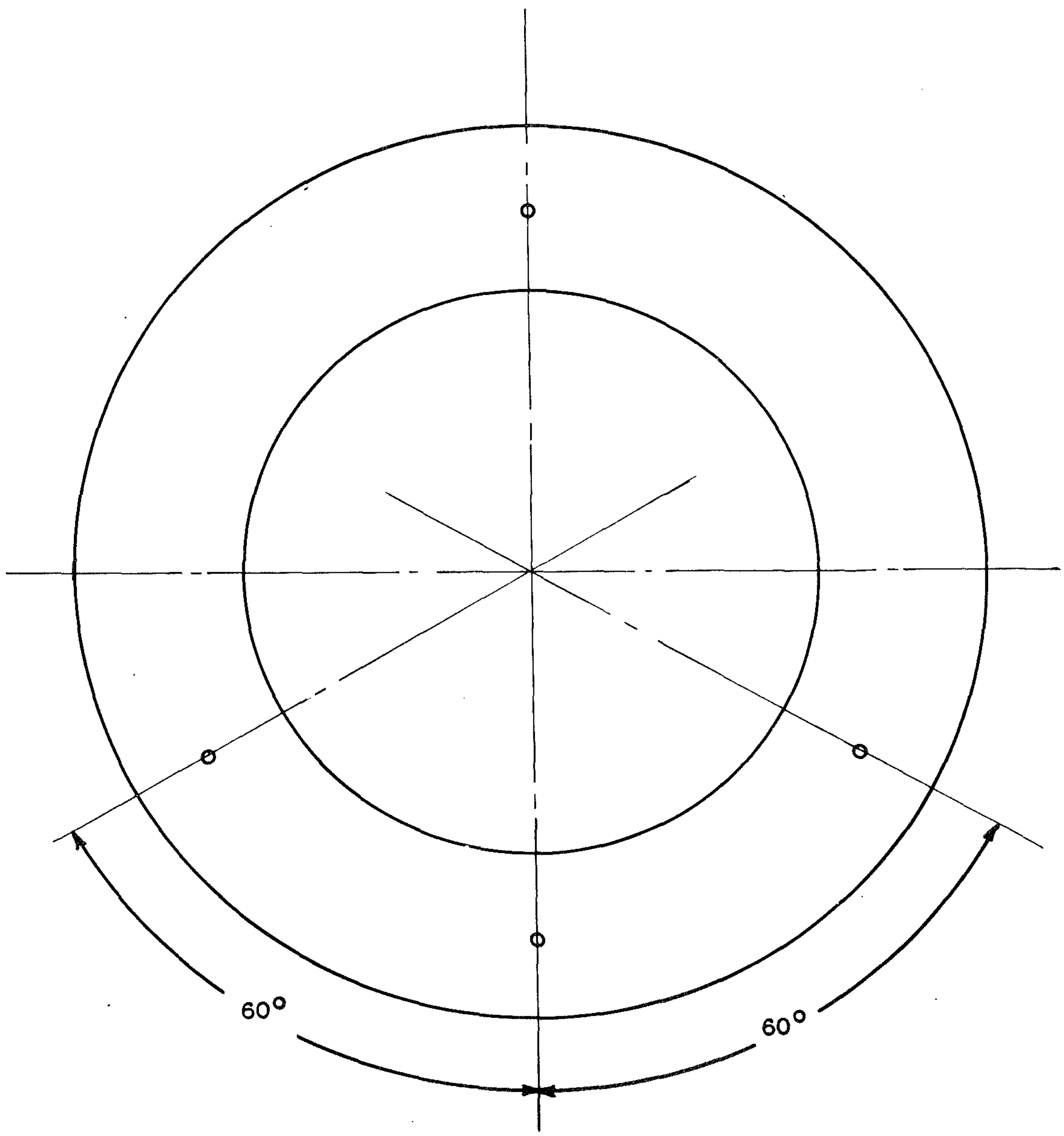
(b) Detail sketch of manufacturer's total-pressure integrating rake.

Figure 8. - Continued. Instrumentation at compressor outlet, station 4, $3\frac{3}{16}$ inches behind trailing edge of compressor-outlet straightening vanes.



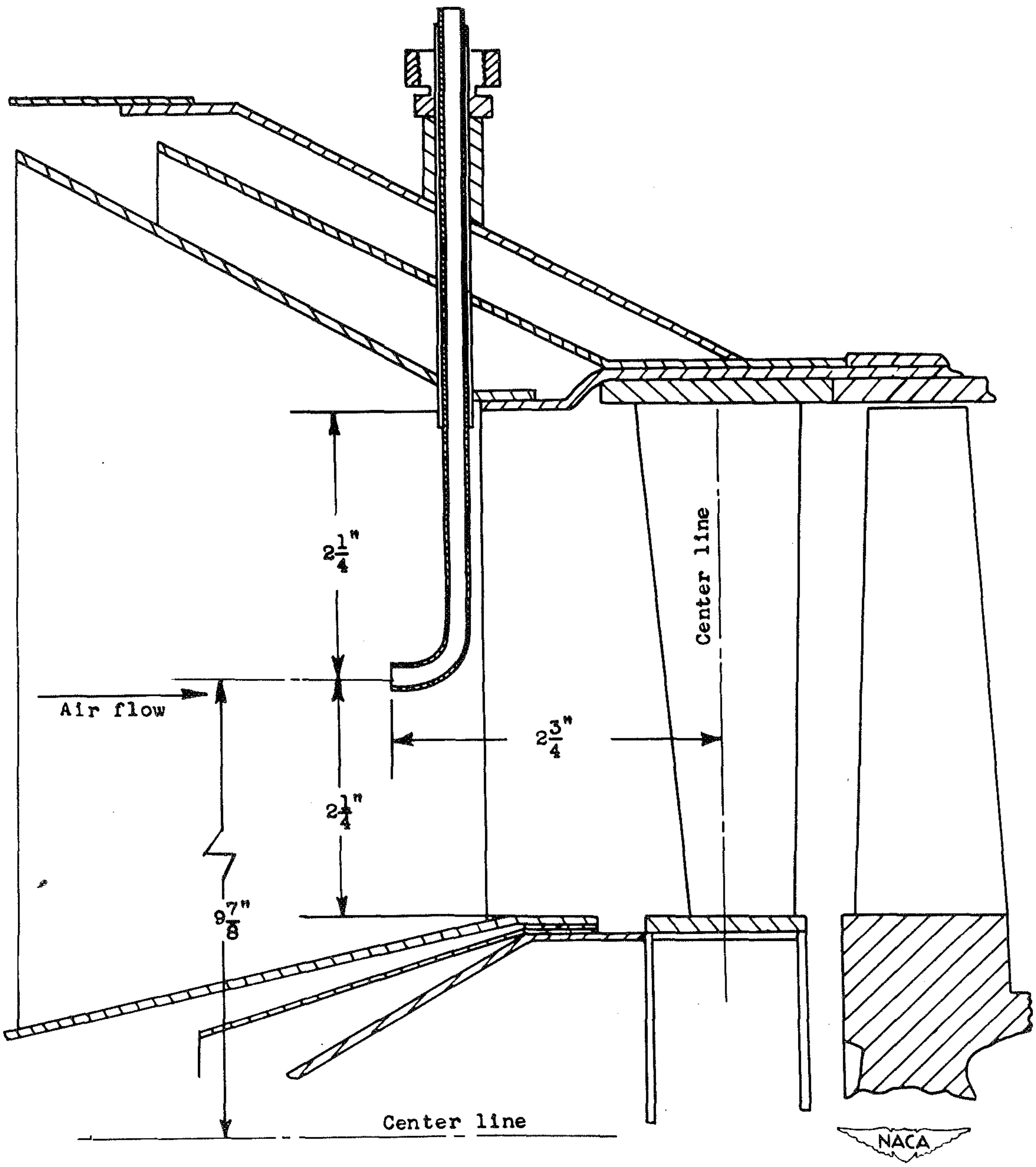
(c) Detail sketch of manufacturer's temperature rake.

Figure 8. - Concluded. Instrumentation at compressor outlet, station 4, $3\frac{13}{16}$ inches behind trailing edge of compressor-outlet straightening vanes.



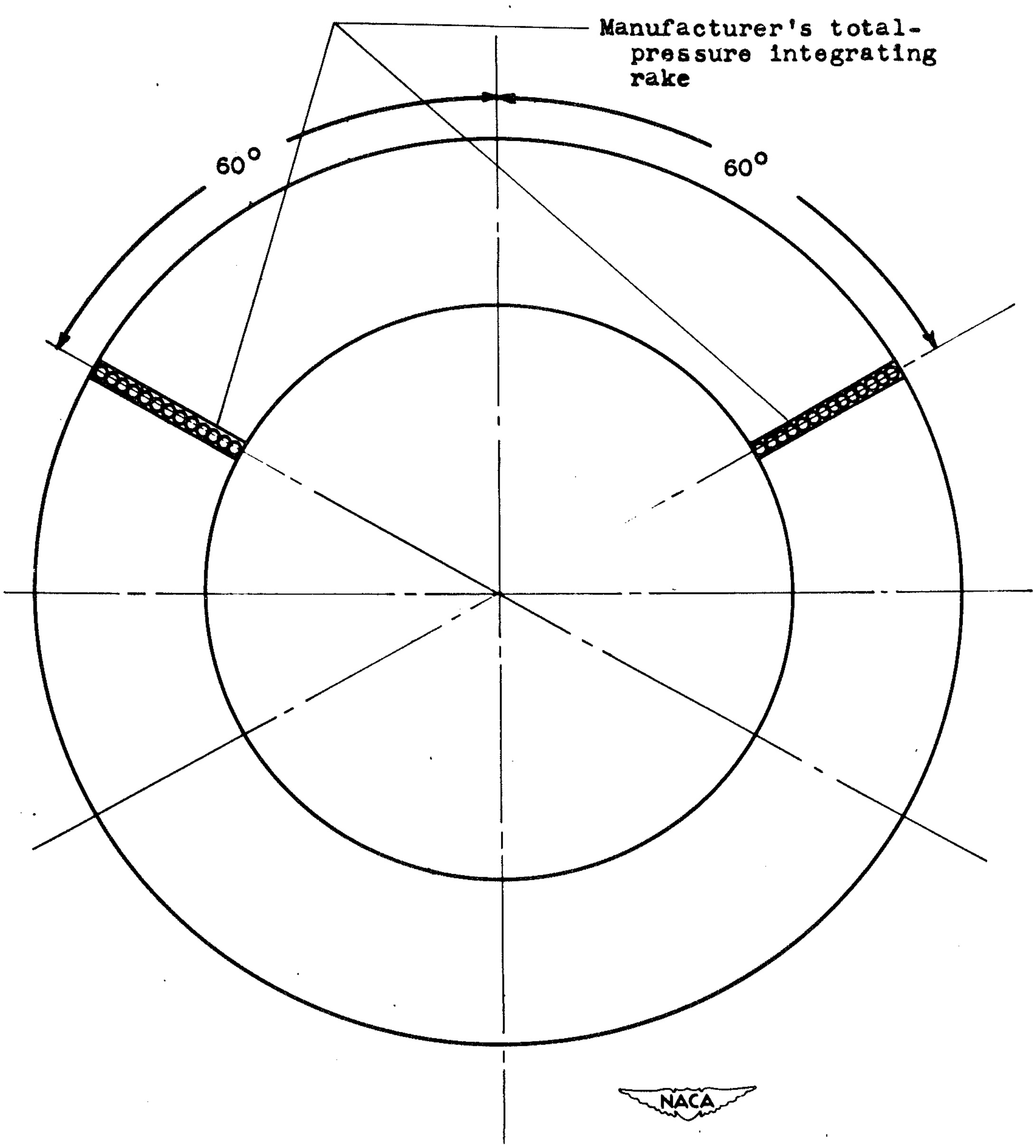
(a) Location of total-pressure tubes.

Figure 9. - Instrumentation at turbine inlet, station 5, $2\frac{3}{4}$ inches in front of center line of first-stage turbine stator blade.



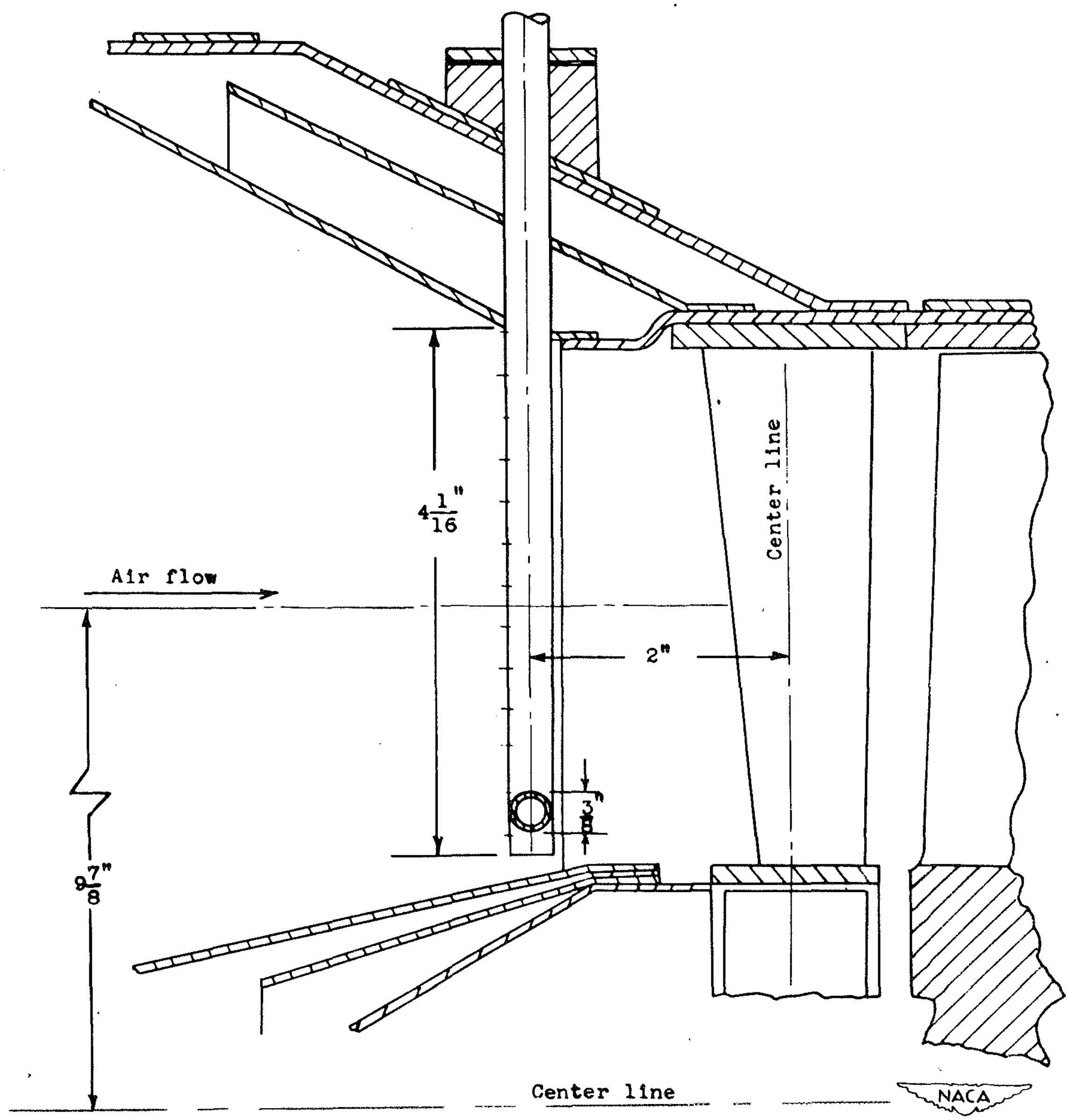
(b) Detail sketch of total-pressure-tube installation.

Figure 9.—Concluded. Instrumentation at turbine inlet, station 5, $2\frac{3}{4}$ inches in front of center line of first-stage turbine stator blade.



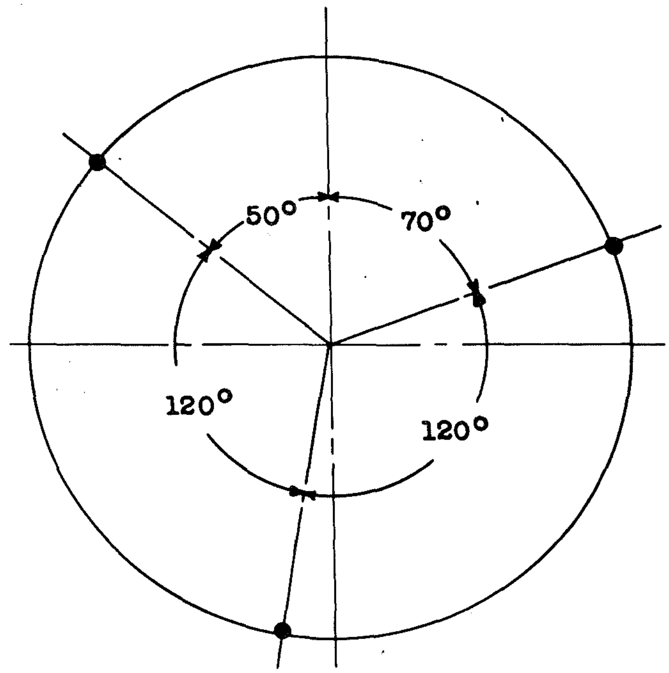
(a) Location of manufacturer's instrumentation.

Figure 10. - Instrumentation at turbine inlet, station 5, $2\frac{3}{16}$ inches in front of center line of first-stage turbine stator blade.

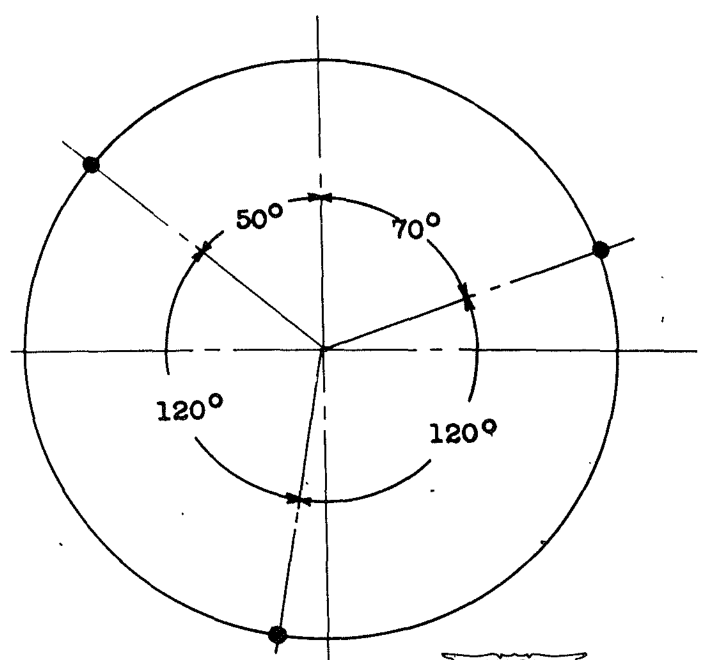


(b) Detail sketch of manufacturer's total-pressure tube.

Figure 10. - Concluded. Instrumentation at turbine inlet, station 5, $2\frac{3}{16}$ inches in front of center line of first-stage turbine stator blade.

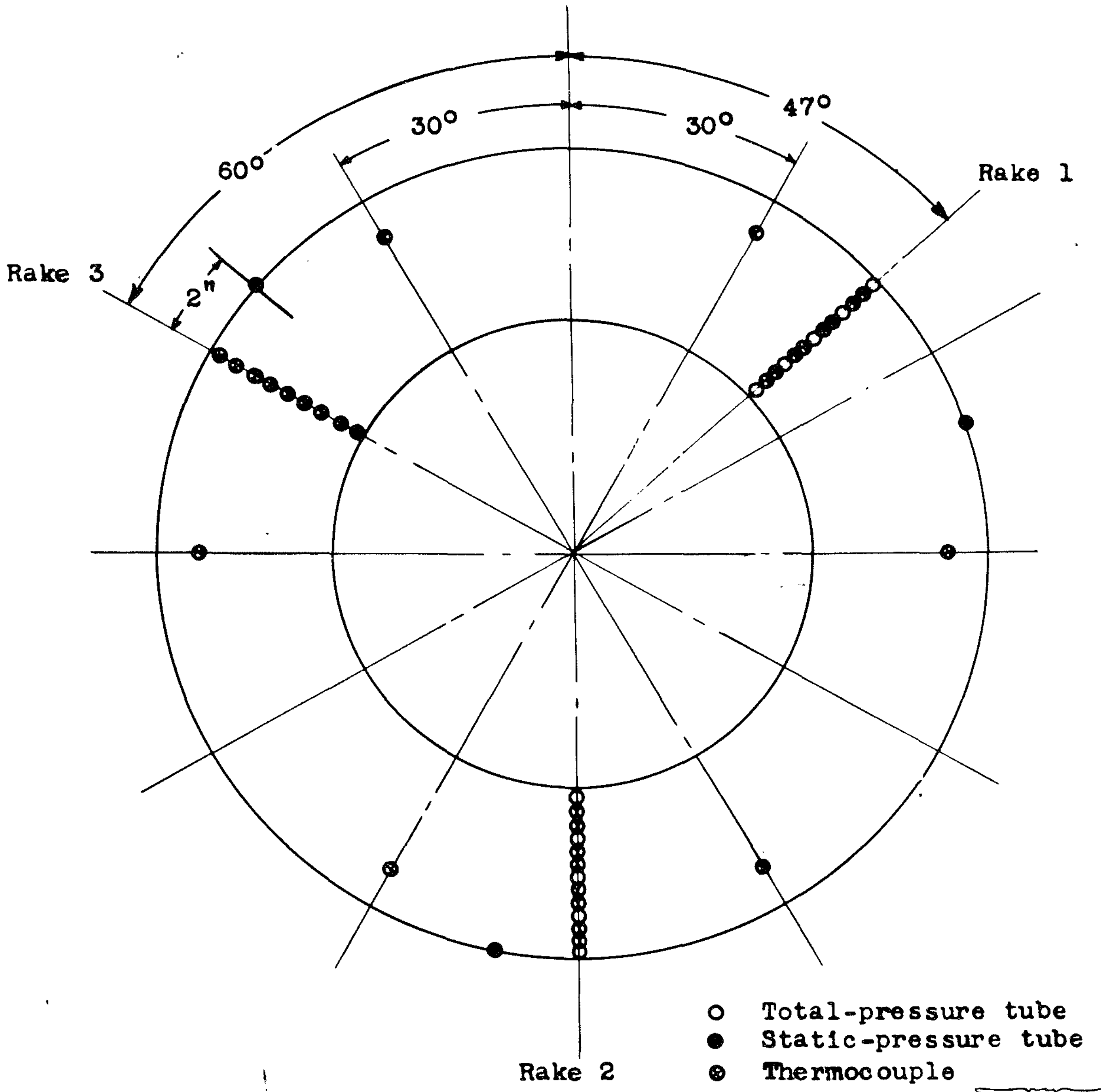


First stage



Second stage

Figure 11. - Location of static-pressure tubes at turbine stator stages, station 6, center line of each stator blade.



(a) Location of instrumentation.

Figure 12. - Instrumentation at turbine outlet, station 7, $3\frac{3}{4}$ inches behind rear flange of turbine casing.

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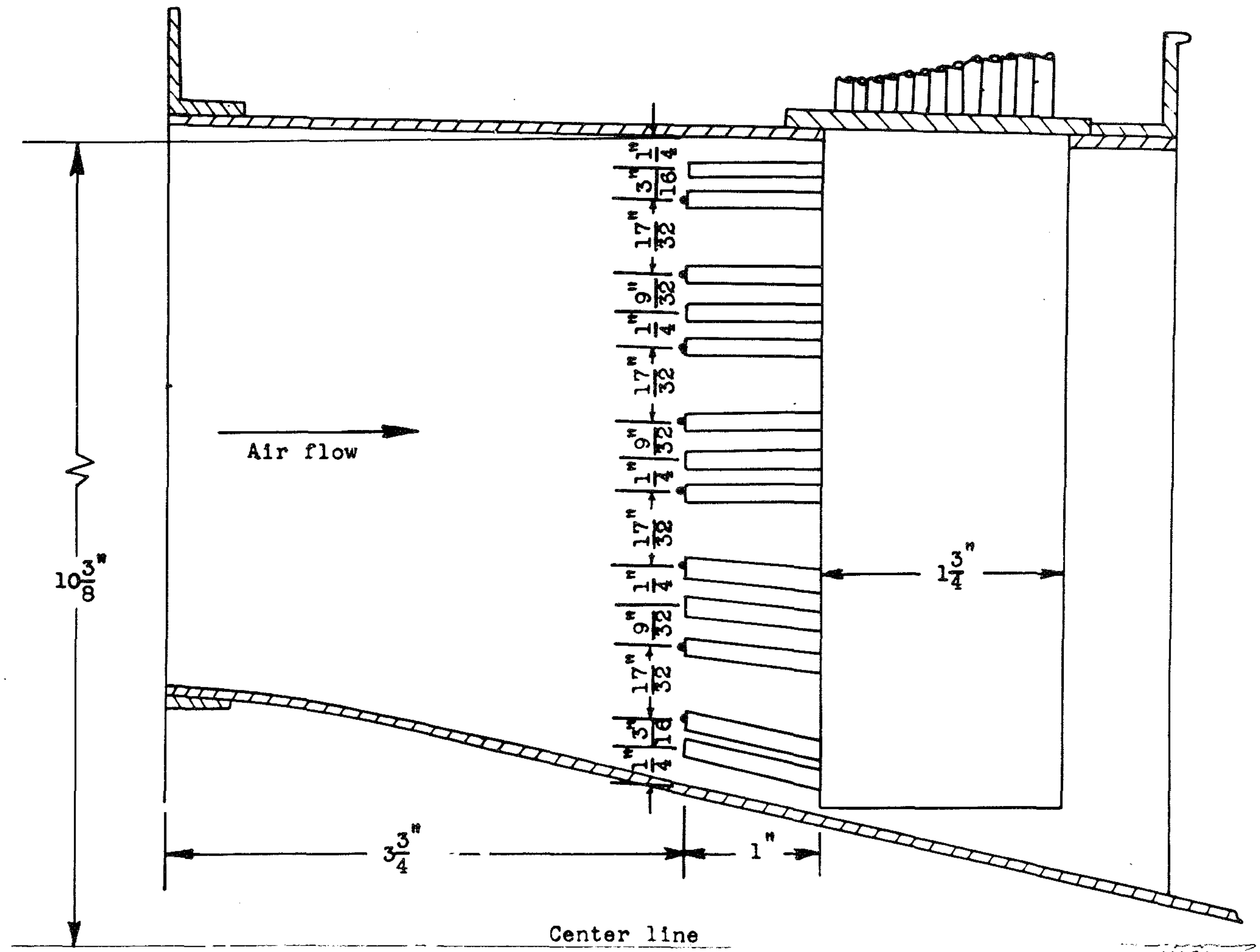

(b) Detail sketch of total-pressure-tube and thermocouple installation.

Figure 12. - Continued. Instrumentation at turbine outlet, station 7, $3\frac{3}{4}$ inches behind rear flange of turbine casing.

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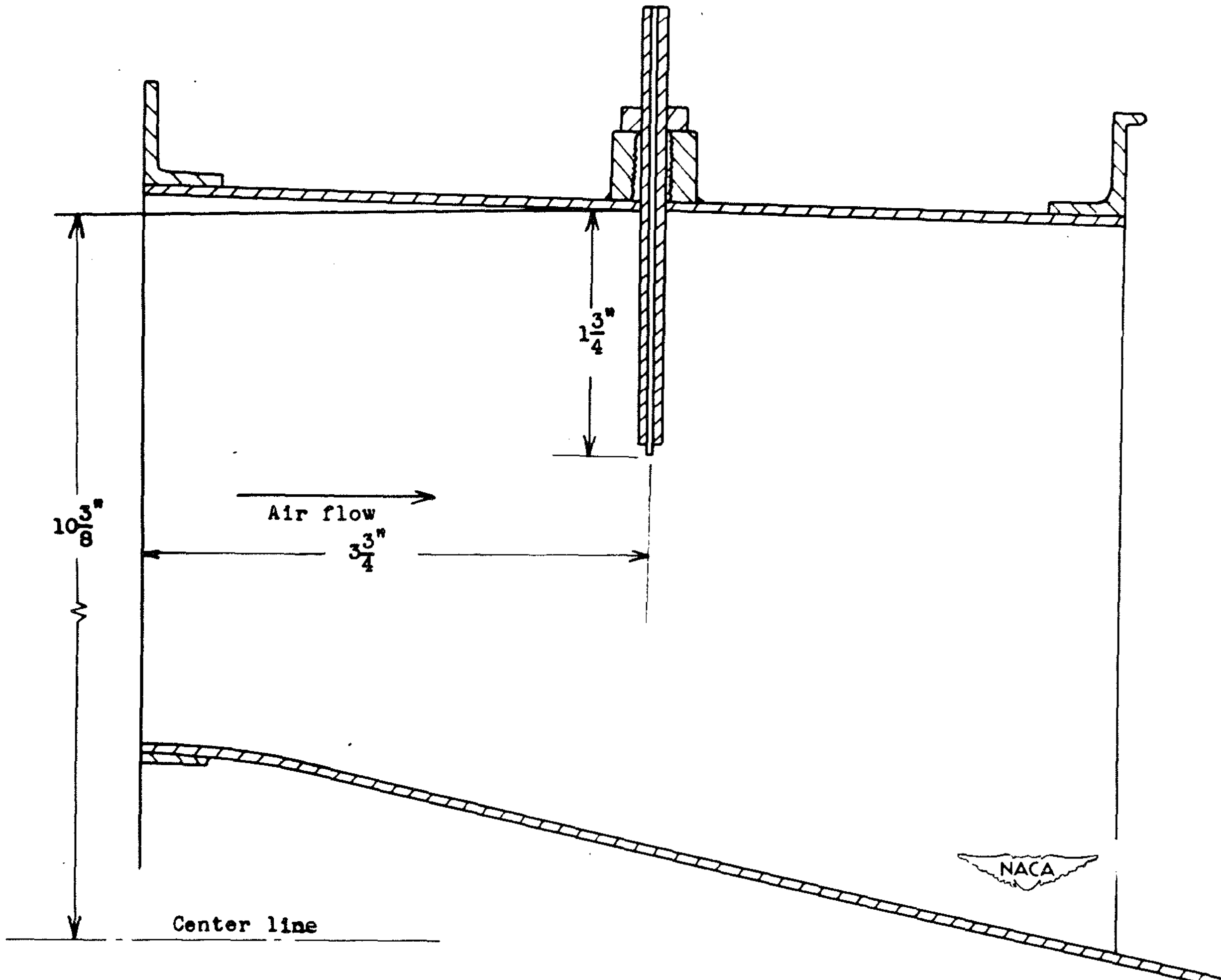

(d) Detail sketch of single-thermocouple installation.

Figure 12. - Concluded. Instrumentation at turbine outlet, station 7, $3\frac{3}{4}$ inches behind rear flange of turbine casing.

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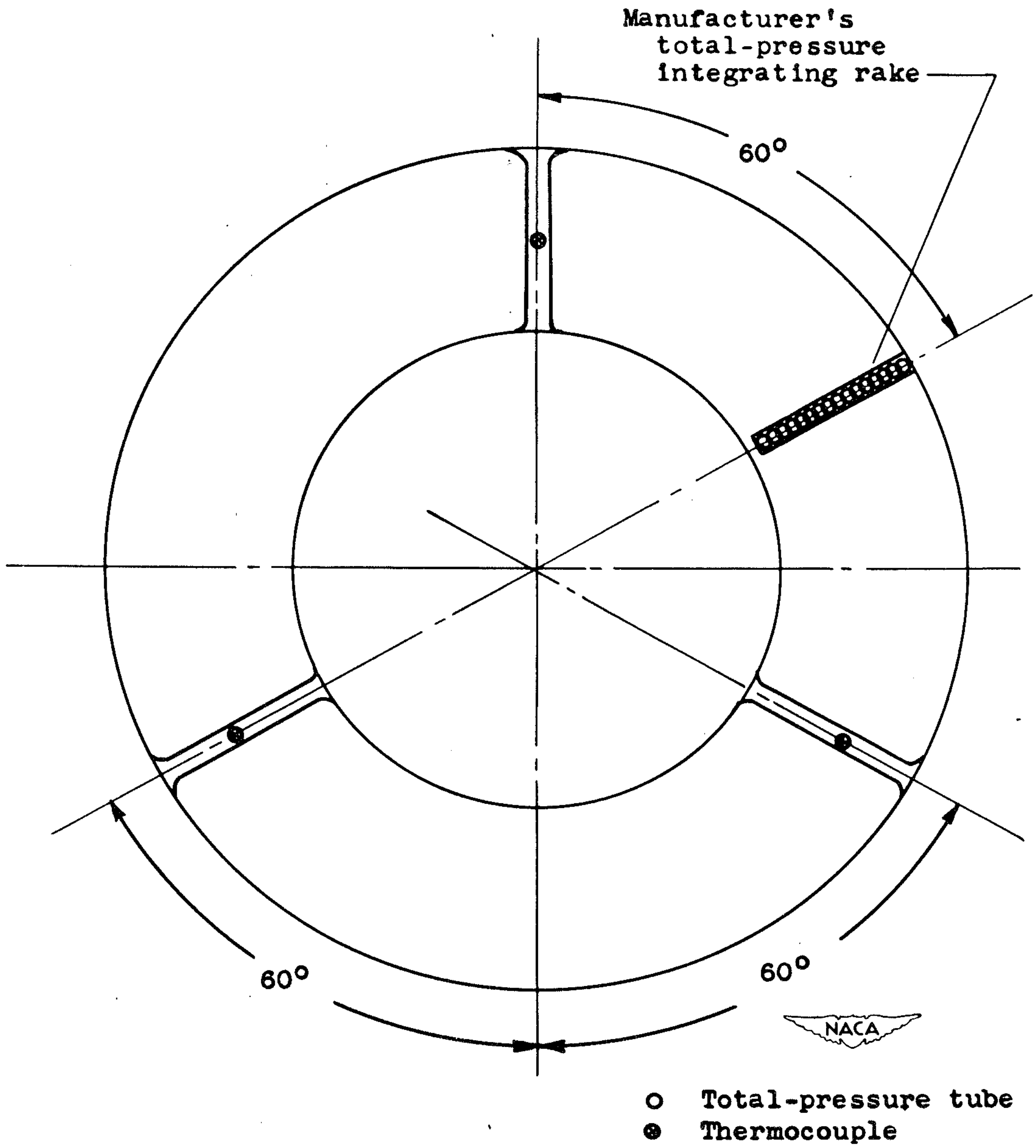
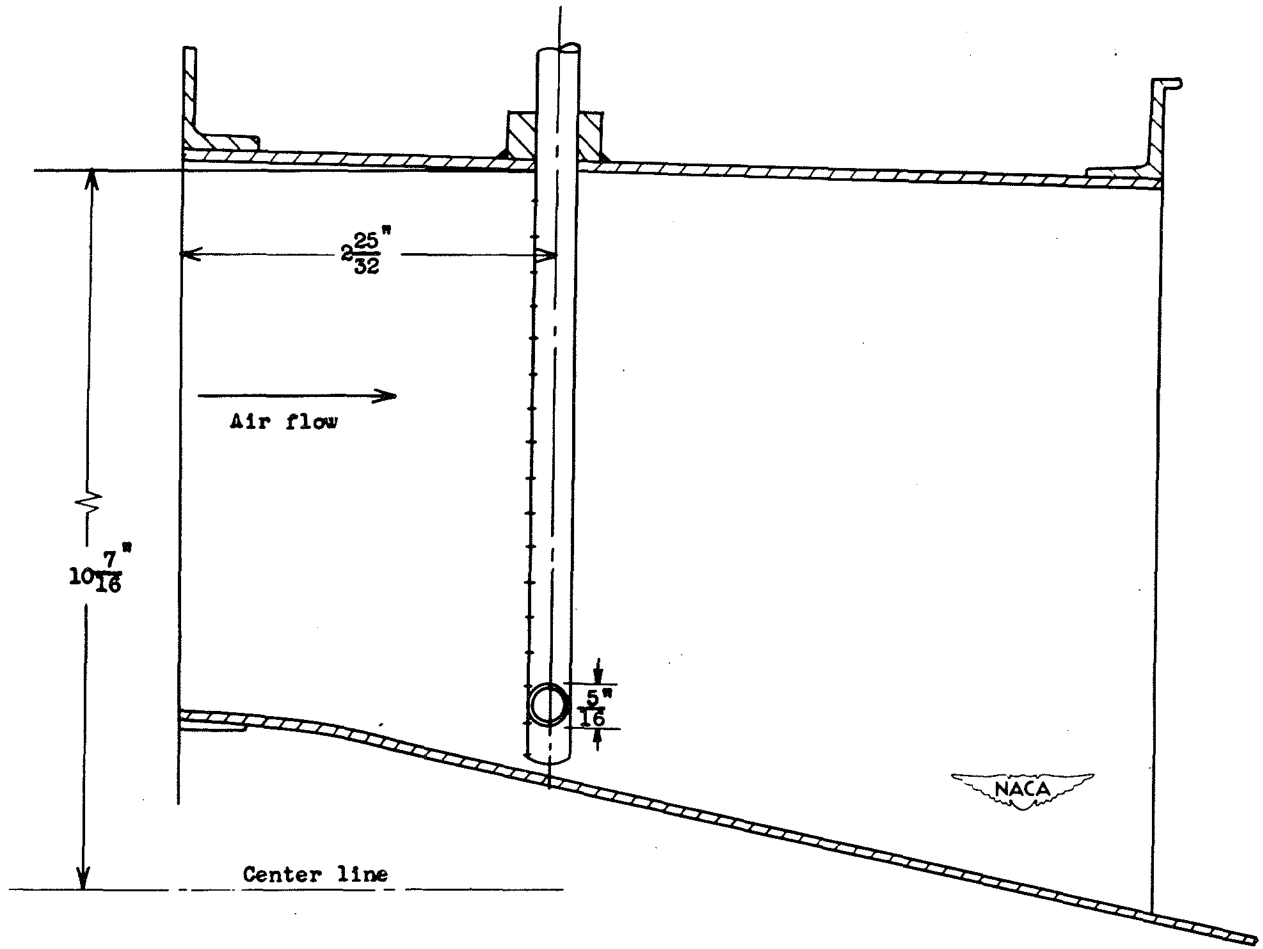


(a) Location of manufacturer's instrumentation.

Figure 13. - Instrumentation at turbine outlet, station 7, $2\frac{5}{8}$ inches behind rear flange of turbine casing.



(b) Detail sketch of manufacturer's total-pressure integrating rake.

Figure 13. - Continued. Instrumentation at turbine outlet, station 7, $2\frac{5}{8}$ inches behind rear flange of turbine casing.

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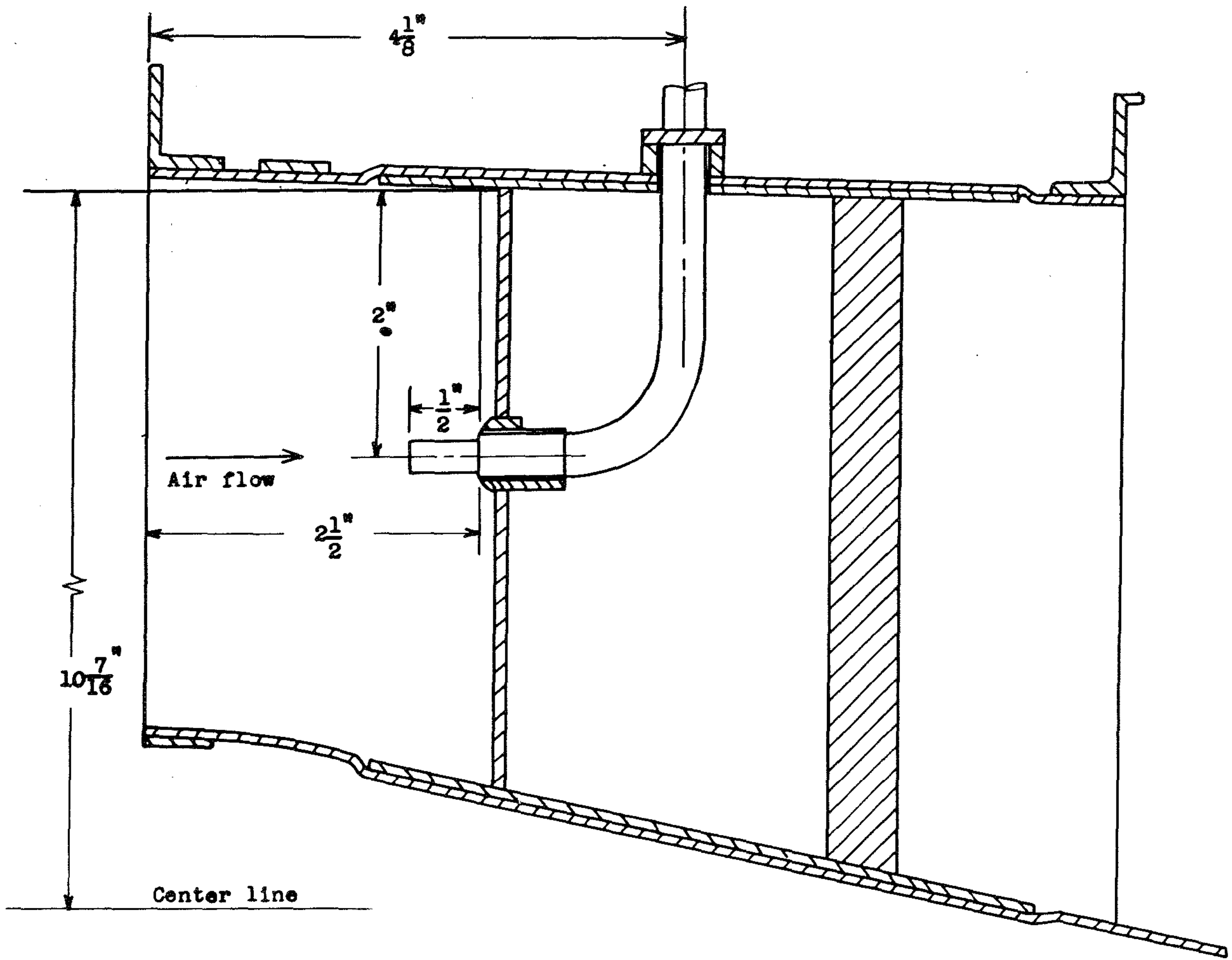
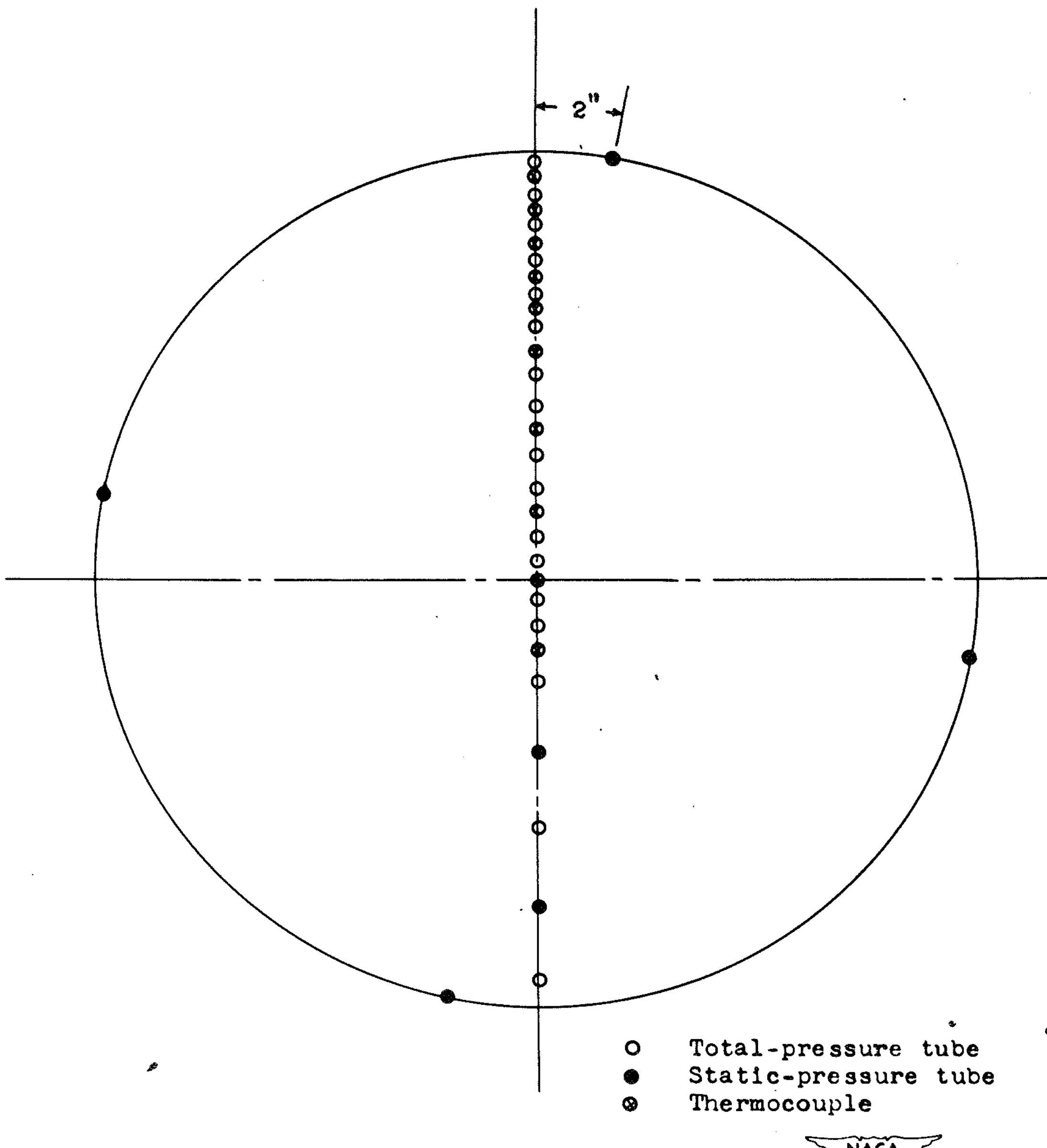


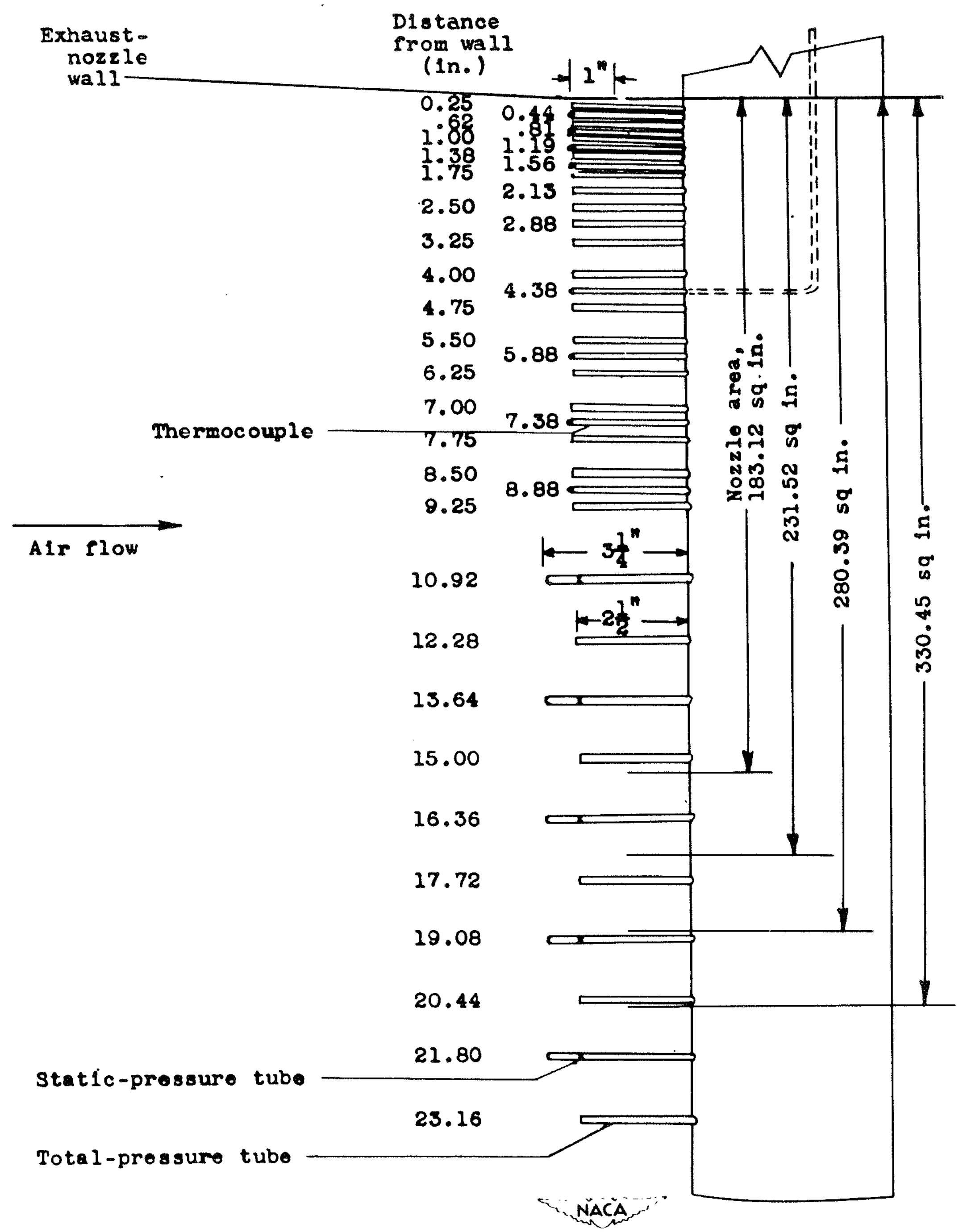
(c) Detail sketch of manufacturer's thermocouple installation.

Figure 13. - Concluded. Instrumentation at turbine outlet, station 7, 2$\frac{5}{8}$ inches behind rear flange of turbine casing.



(a) Location of instrumentation.

Figure 14. - Instrumentation in exhaust-nozzle outlet, station 8, 1 inch in front of rear edge of exhaust-nozzle outlet.



(b) Detail sketch of pressure and temperature survey rake.

Figure 14. - Concluded. Instrumentation in exhaust-nozzle outlet, station 8, 1 inch in front of rear edge of exhaust-nozzle outlet.

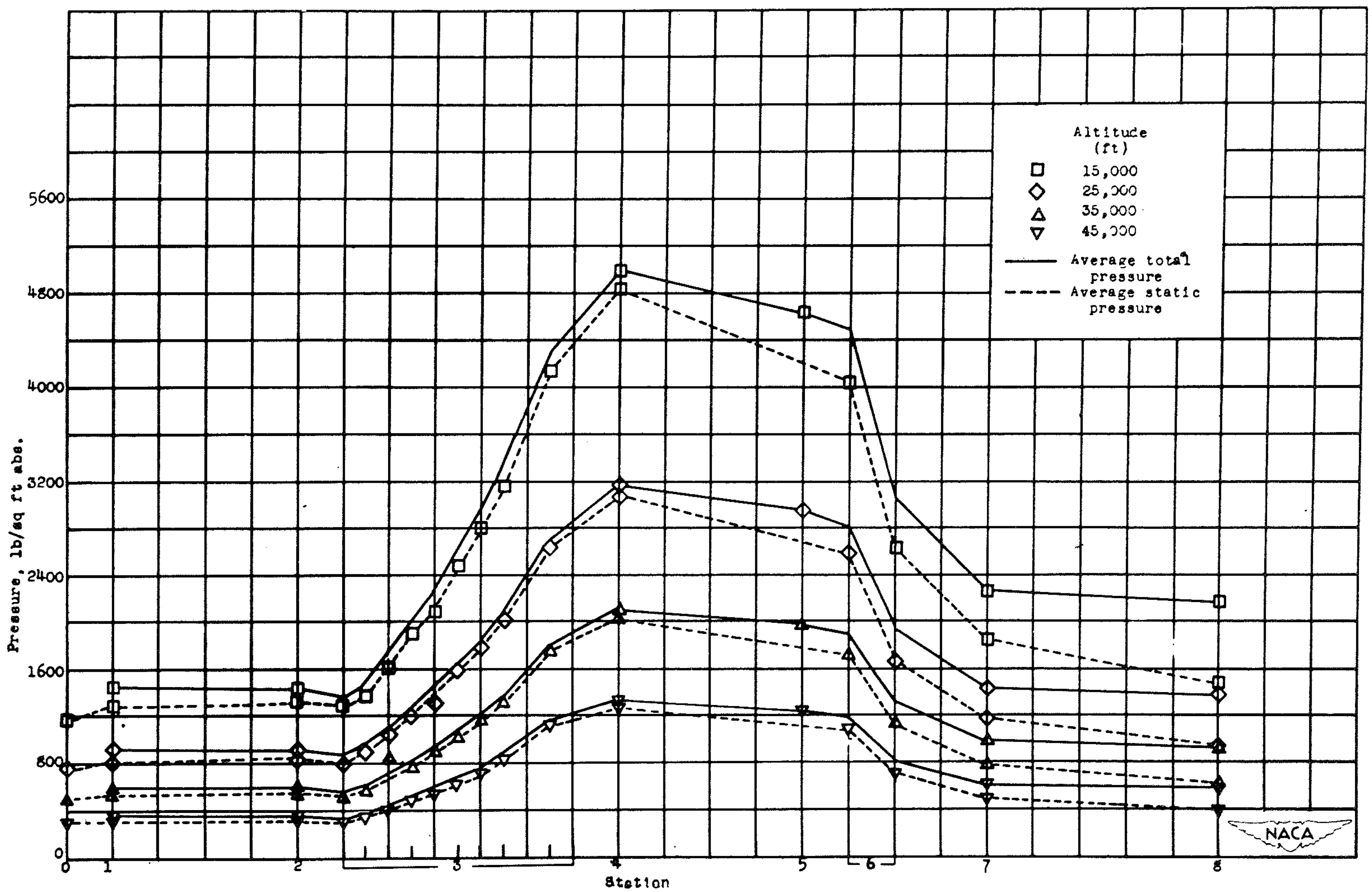


Figure 15. - Variation of average total and static pressures through engine for several altitudes. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

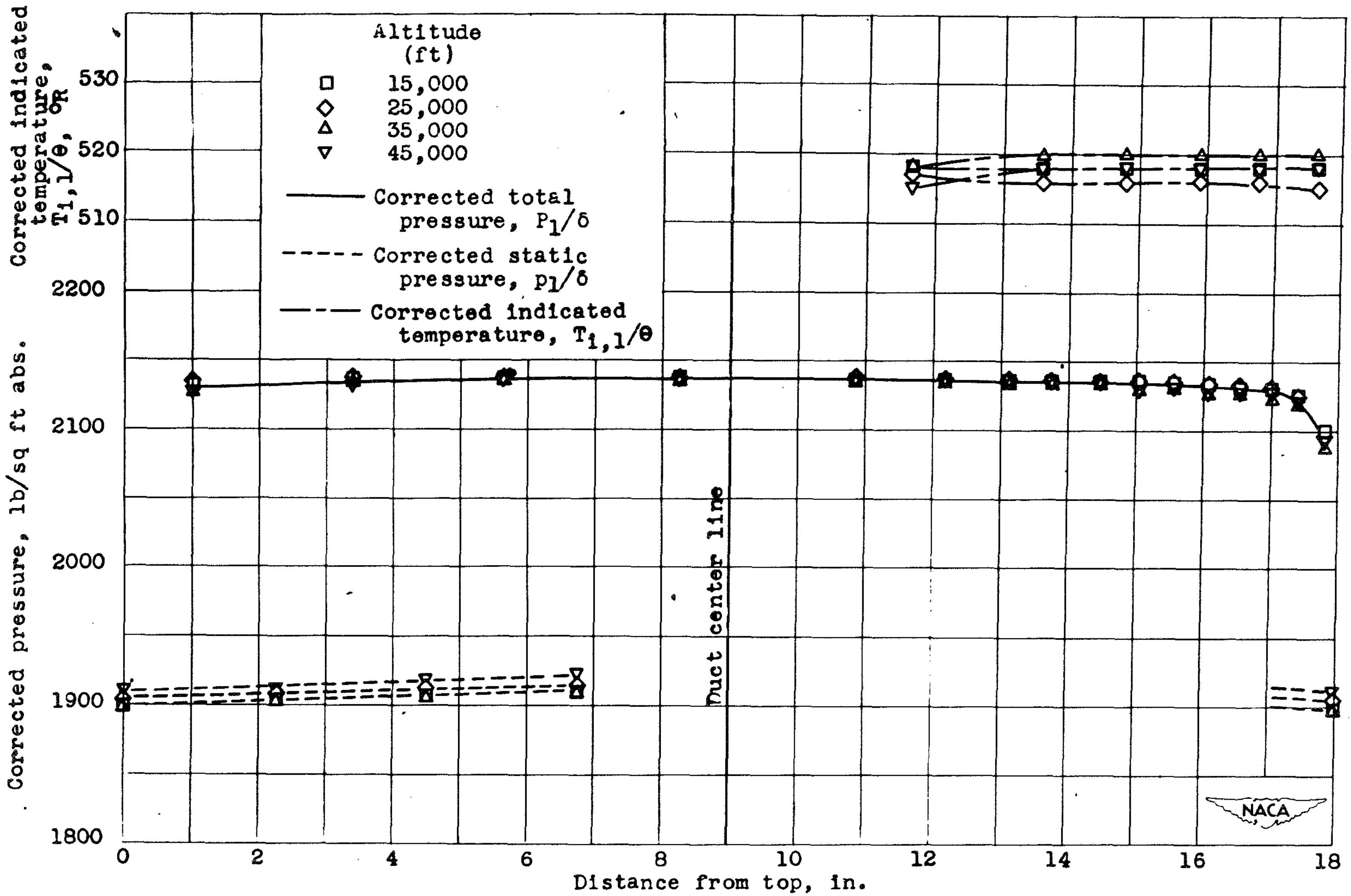


Figure 16. - Effect of altitude on corrected total-pressure, static-pressure, and indicated-temperature distribution at cowl inlet, station 1. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

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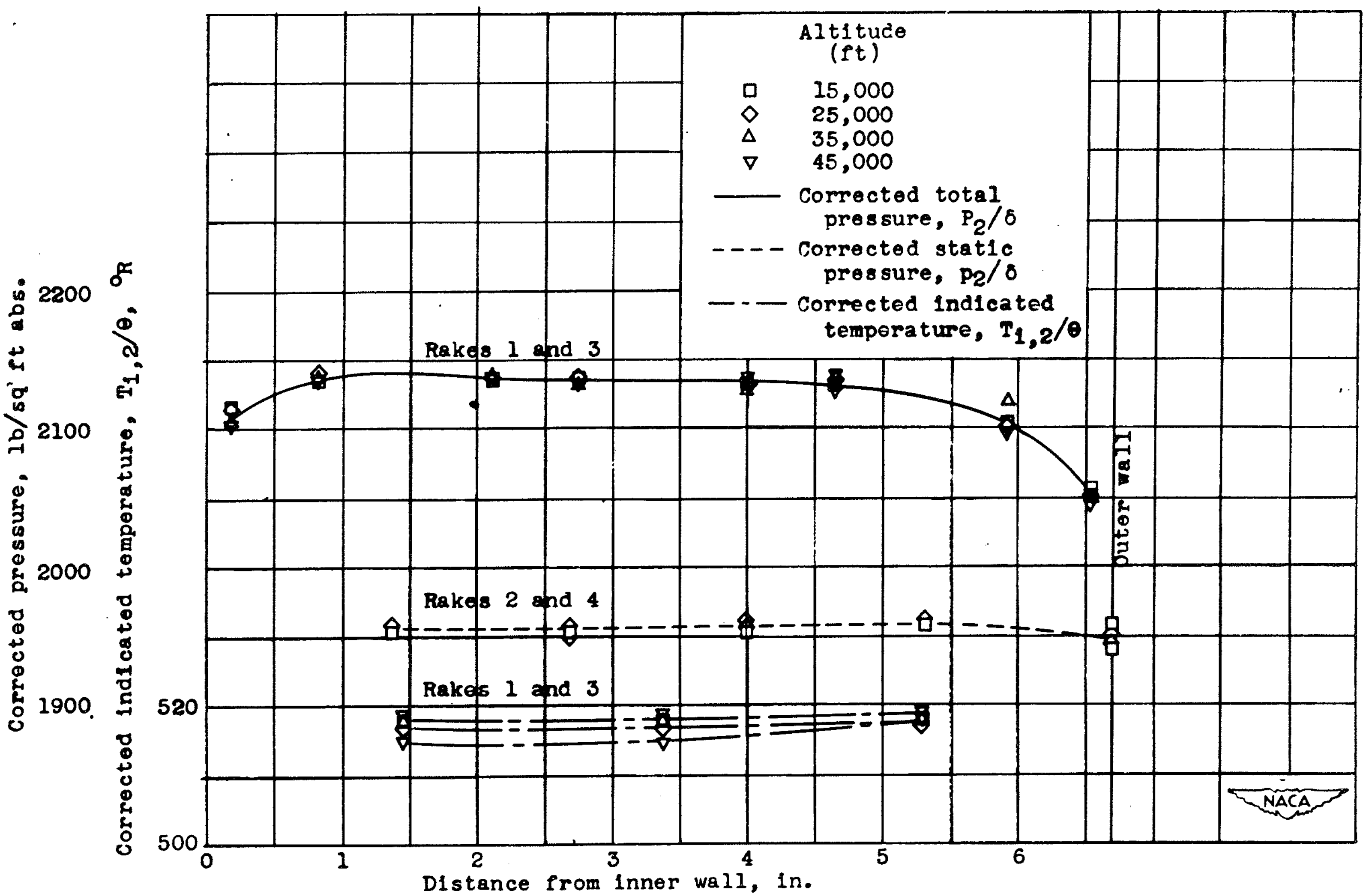

Figure 17. - Effect of altitude on radial and circumferential distribution of corrected total pressure, static pressure, and indicated temperature at compressor inlet, station 2. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

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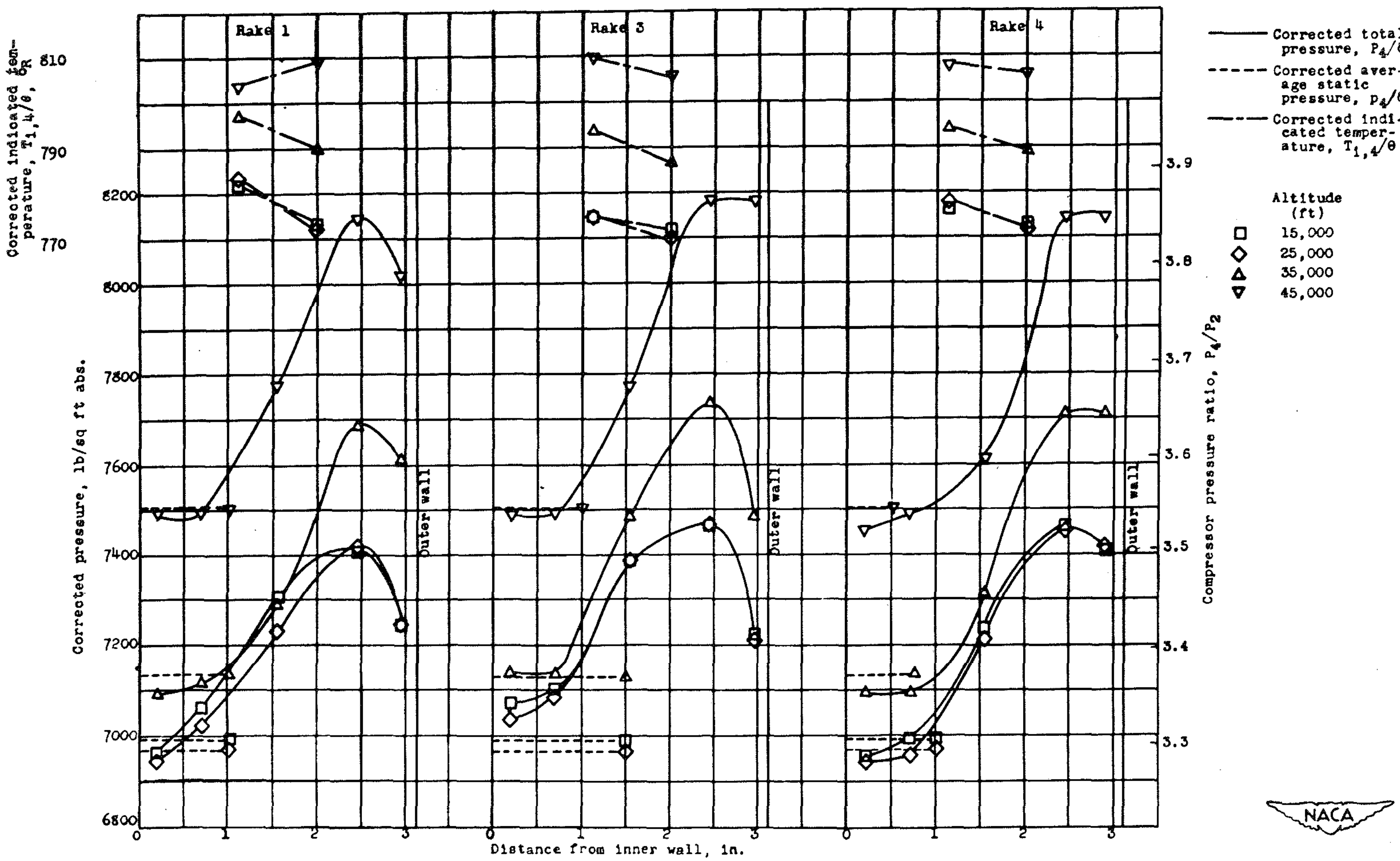

Figure 18. - Effect of altitude on radial distribution of corrected total pressure, static pressure, and indicated temperature at compressor outlet, station 4. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

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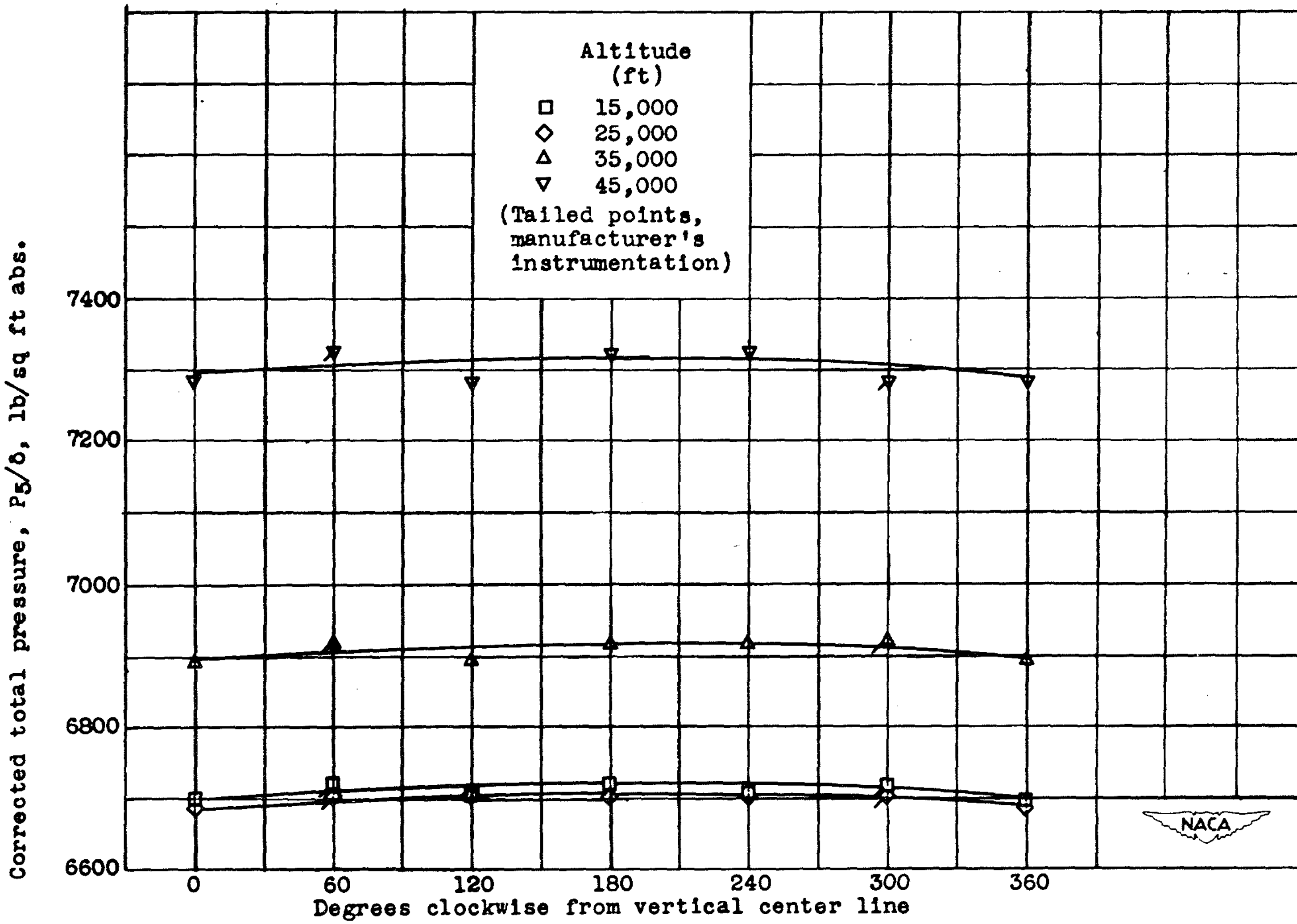

Figure 19. - Effect of altitude on circumferential distribution of corrected total pressure at turbine inlet, station 5. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

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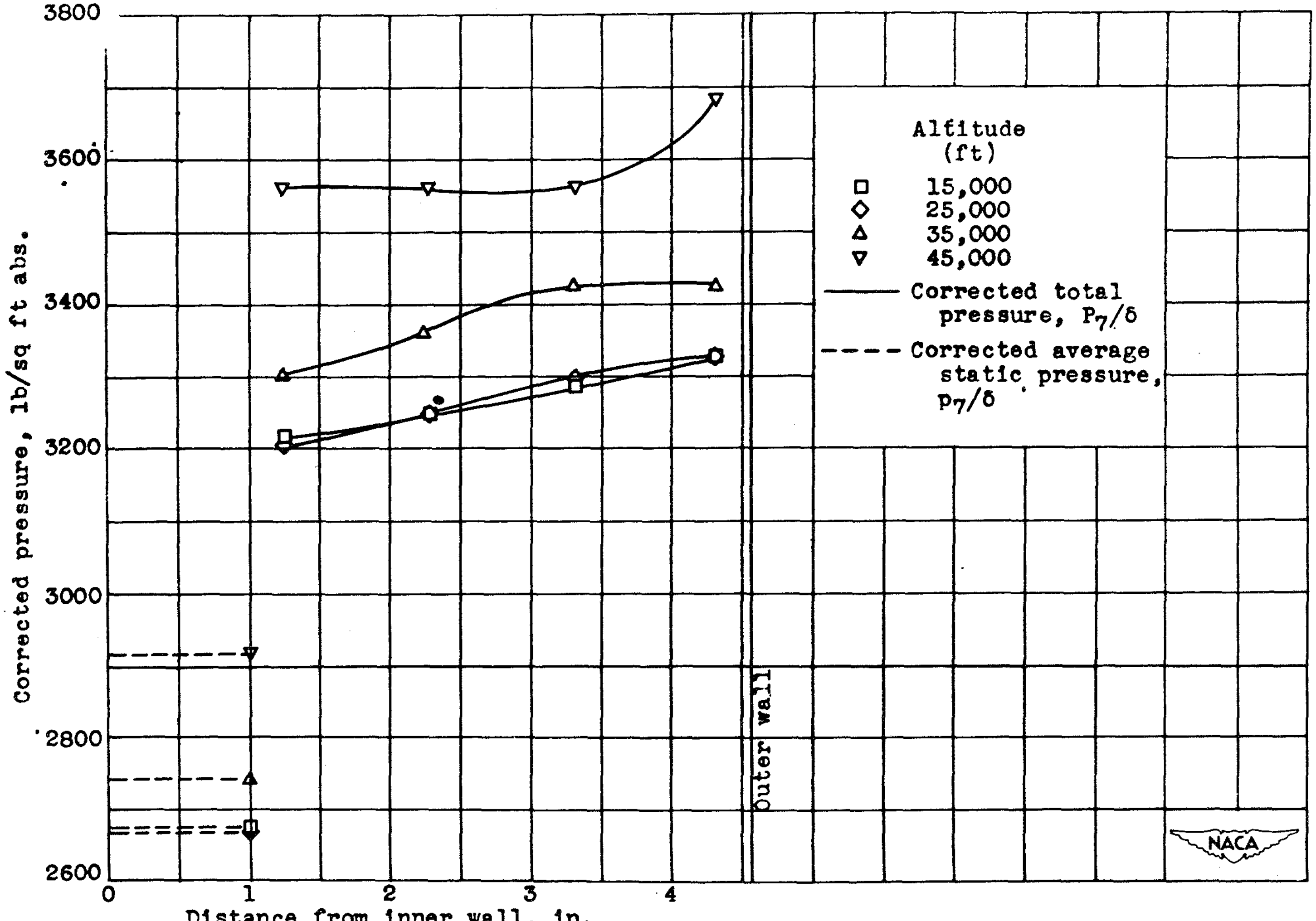

Figure 20. - Effect of altitude on radial distribution of corrected total pressure at turbine outlet, station 7. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

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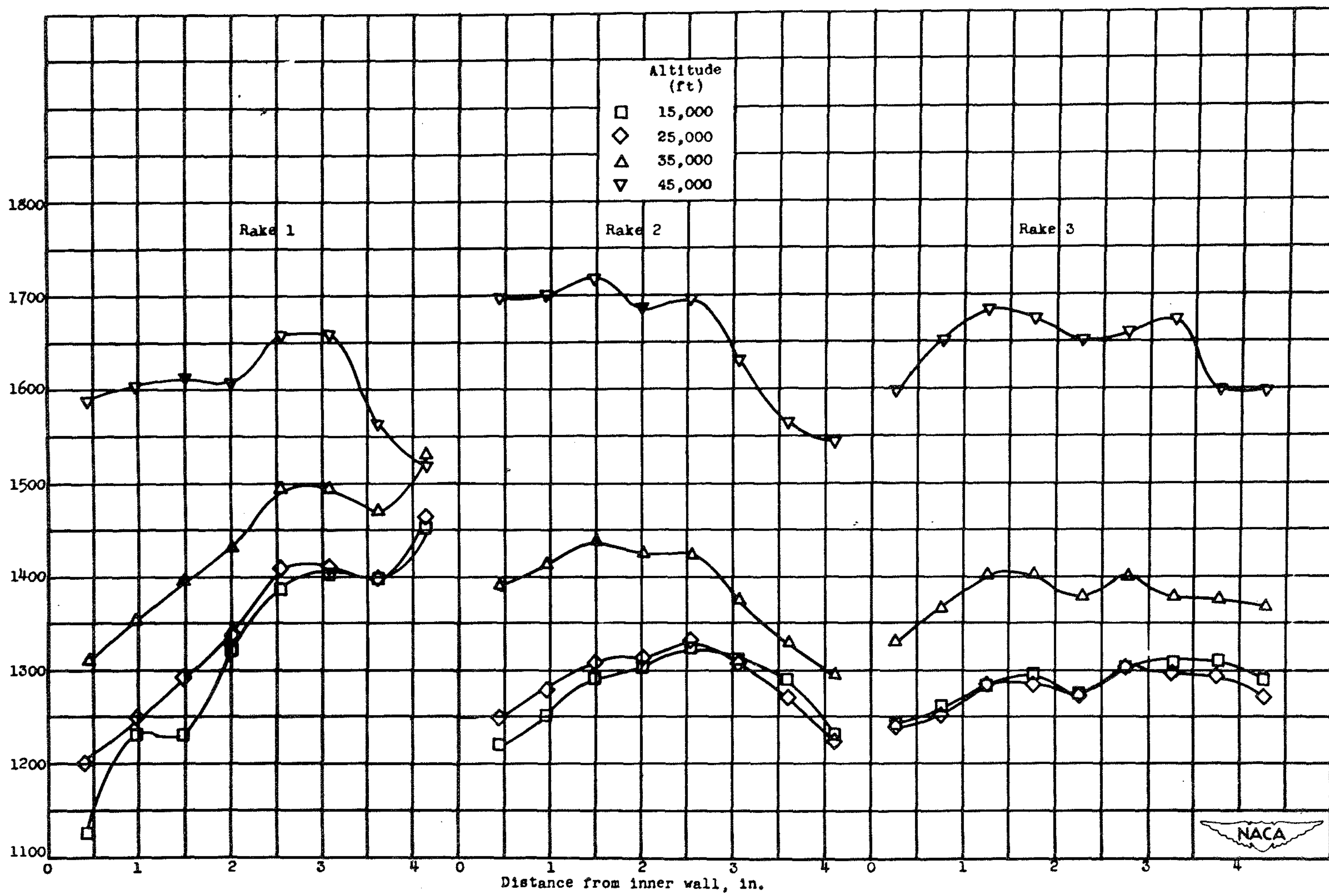

(a) Radial distribution.

Figure 21. - Effect of altitude on corrected indicated temperature at turbine outlet, station 7. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

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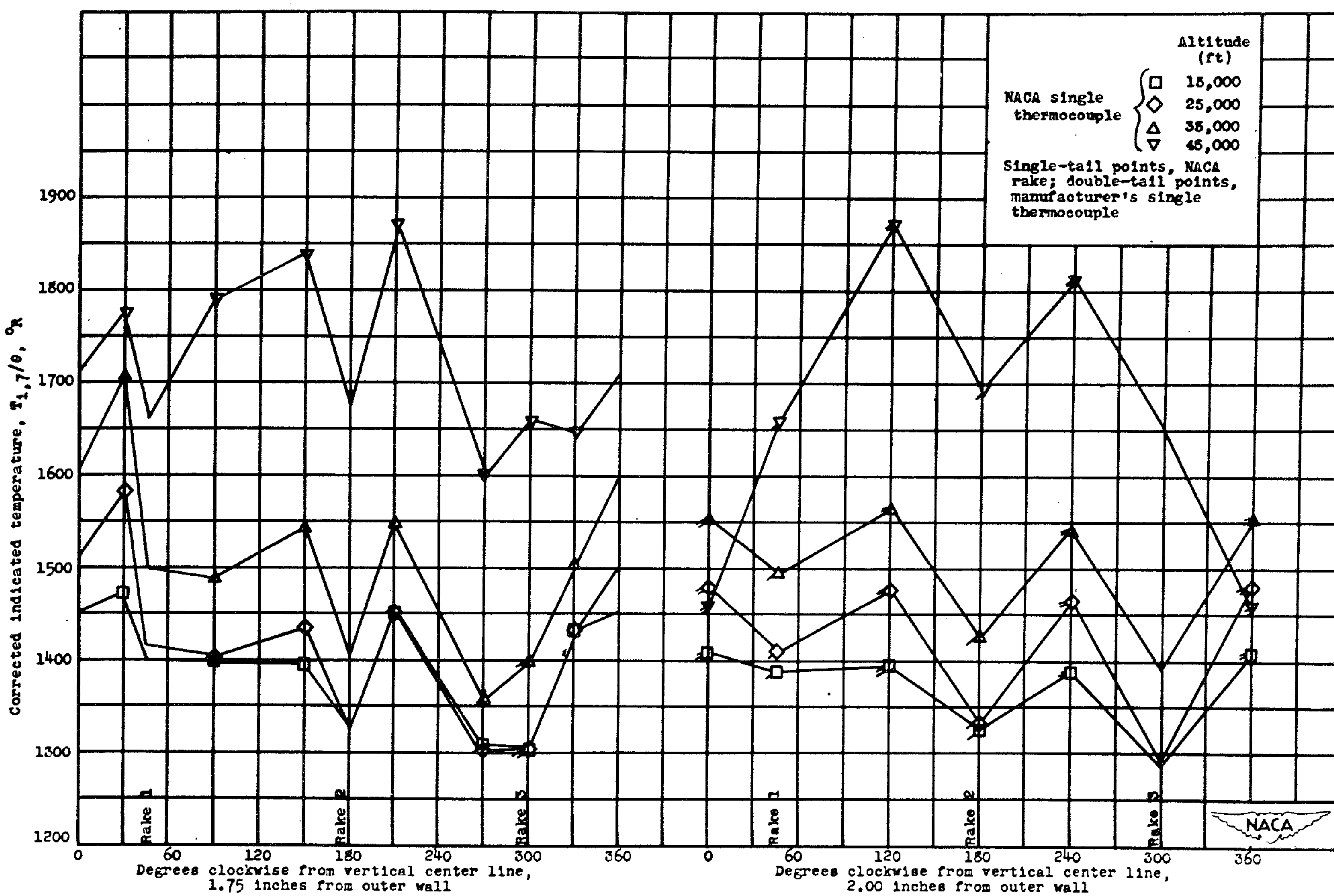

(b) Circumferential distribution.

Figure 21. - Concluded. Effect of altitude on corrected indicated temperature at turbine outlet, station 7. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

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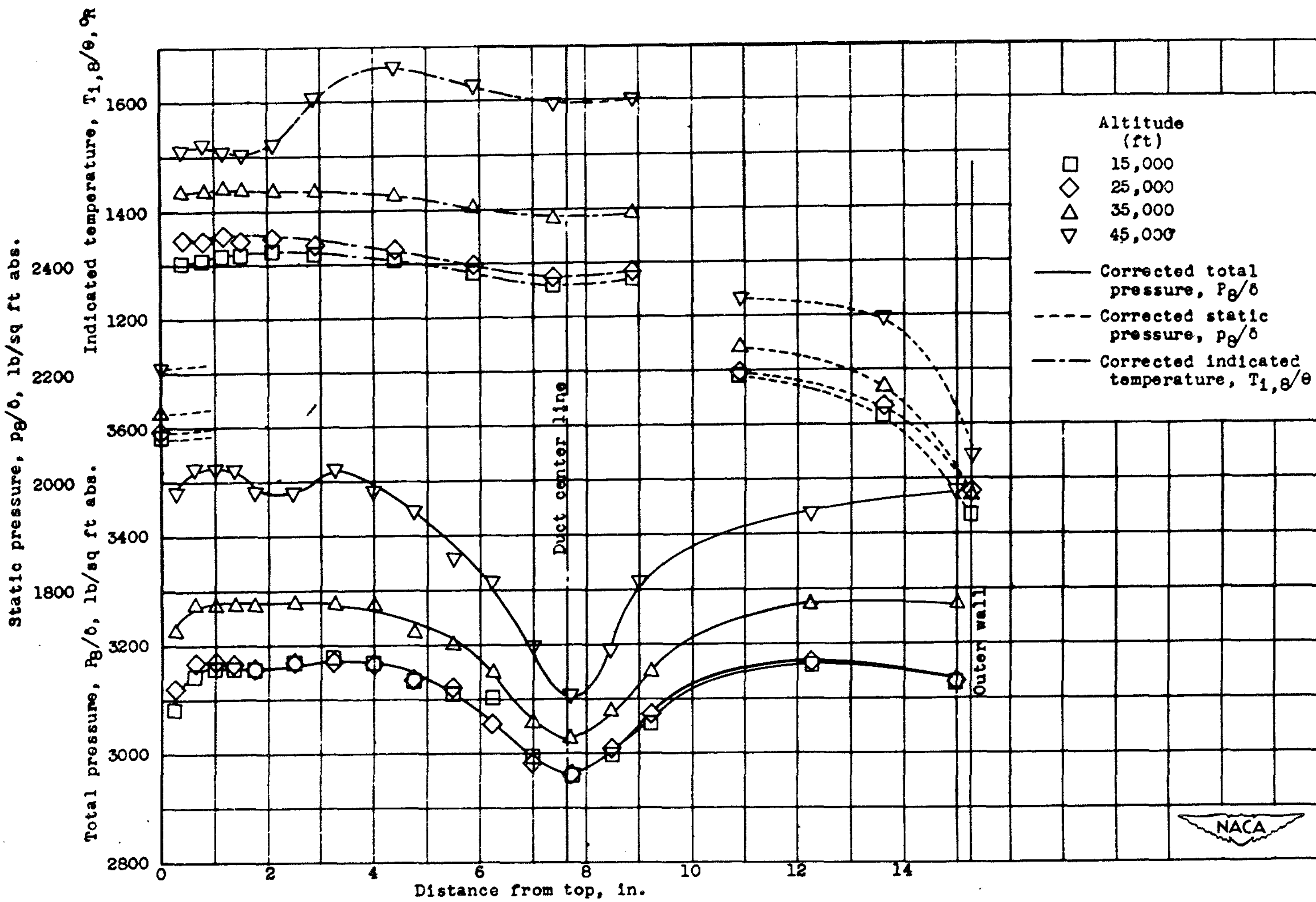

Figure 22. - Effect of altitude on corrected total-pressure, static-pressure, and indicated-temperature distribution at exhaust-nozzle outlet, station 8. Mach number, approximately 0.53; average corrected engine speed, 11,855 rpm.

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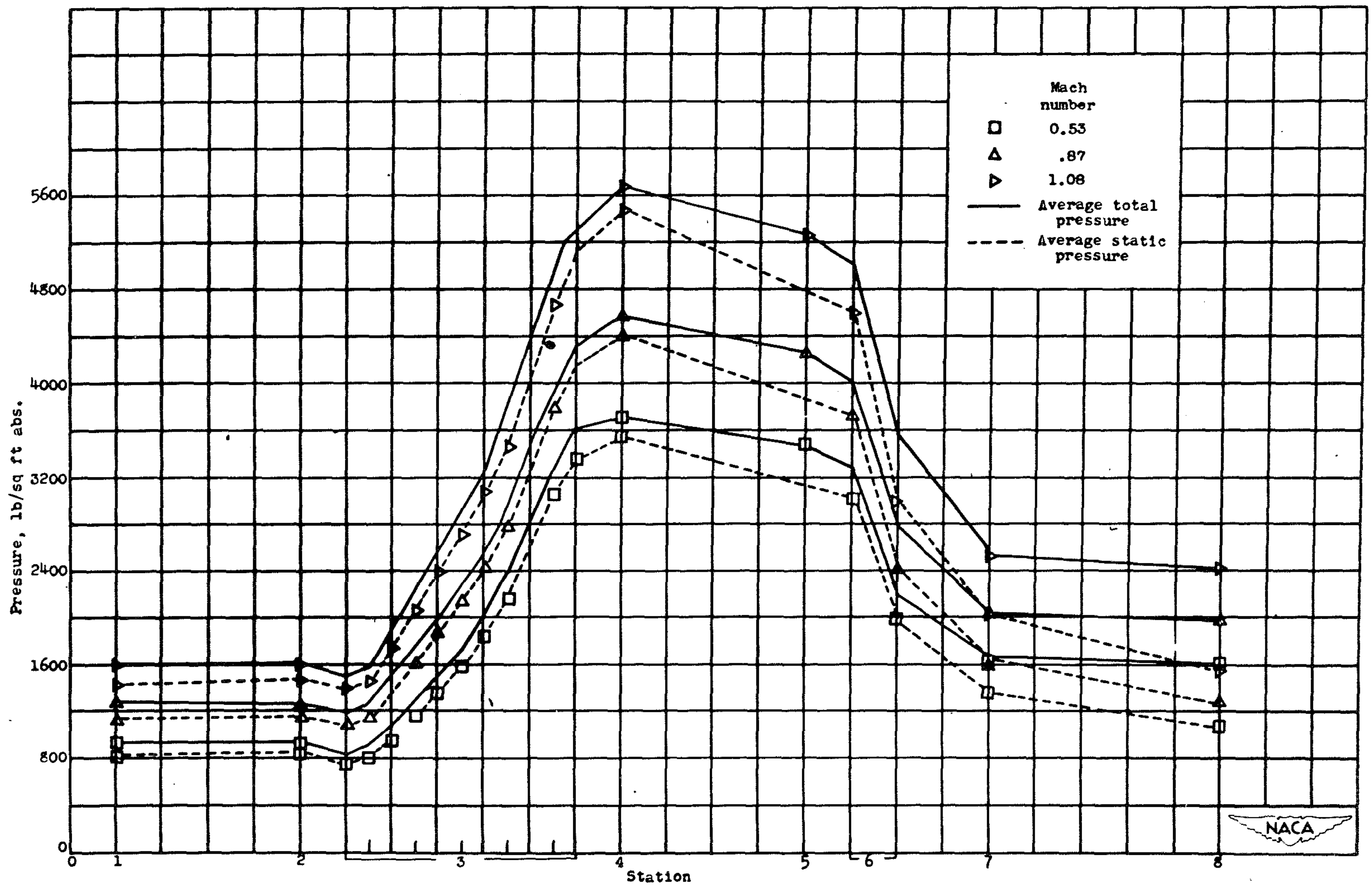

Figure 23. - Variation of average total and static pressures through engine with Mach number. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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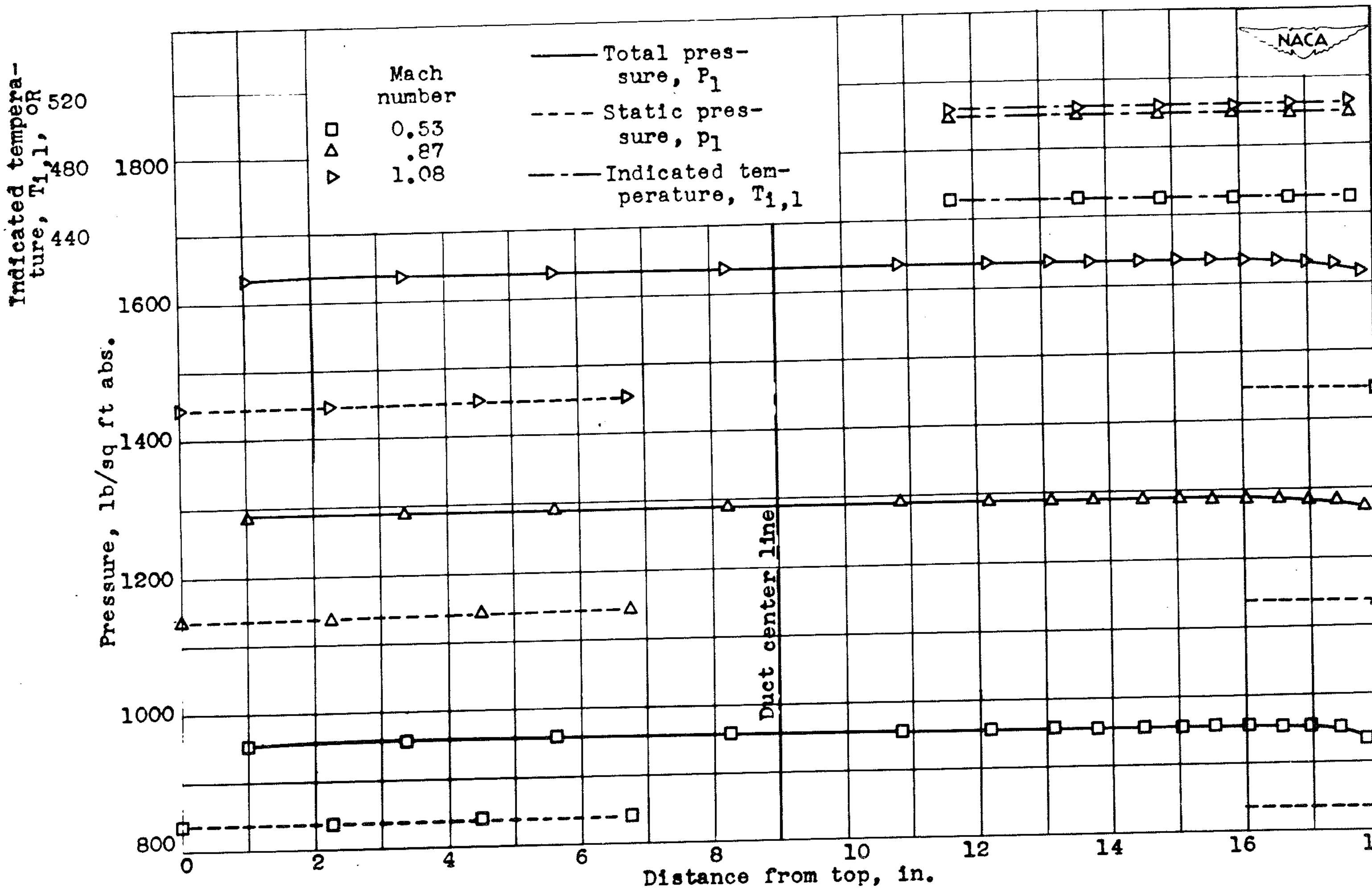

Figure 24. - Effect of Mach number on total-pressure, static-pressure, and indicated-temperature distribution at cowl inlet, station 1. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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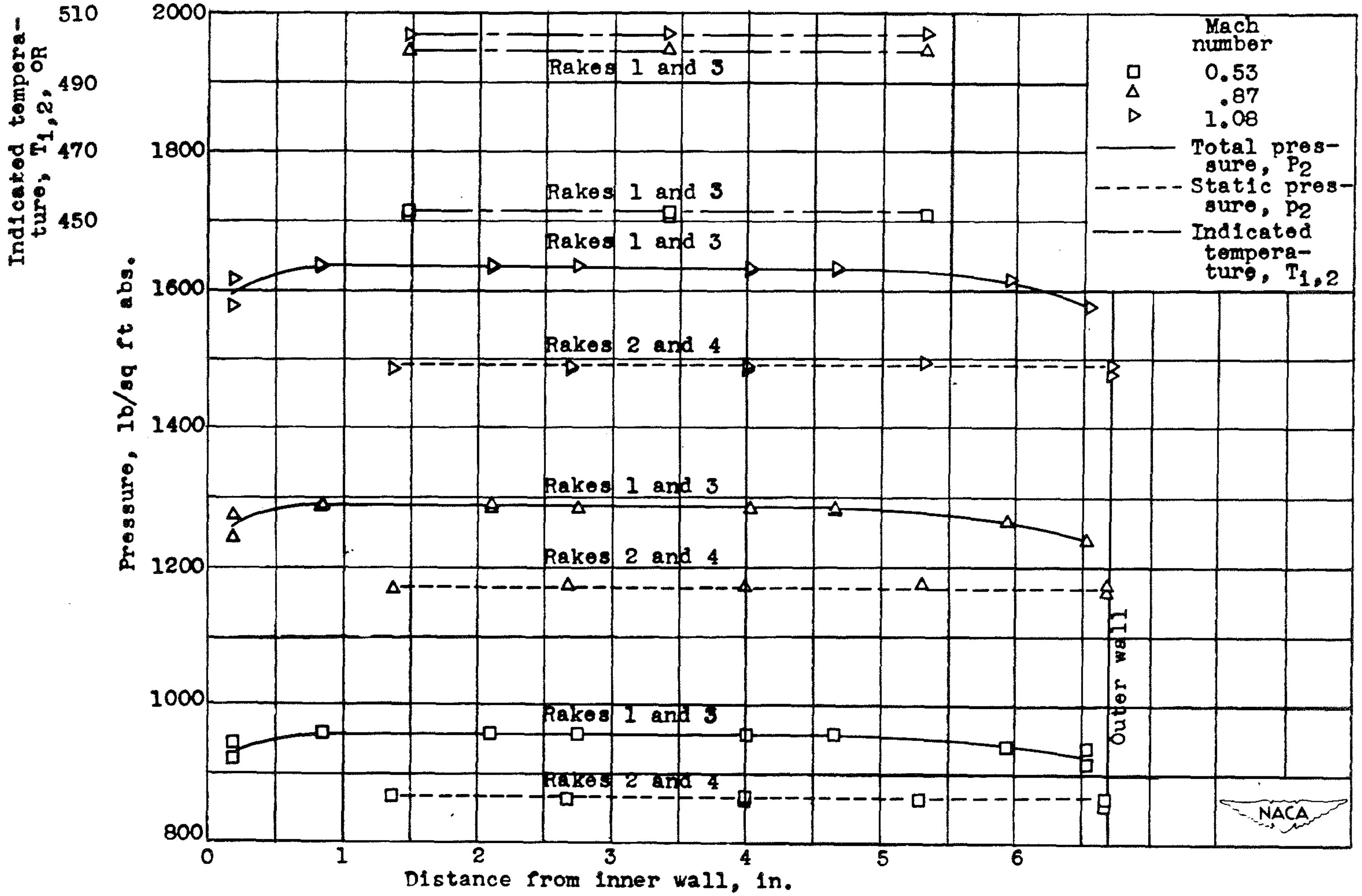

Figure 25. - Effect of Mach number on radial and circumferential distribution of total pressure, static pressure, and indicated temperature at compressor inlet, station 2. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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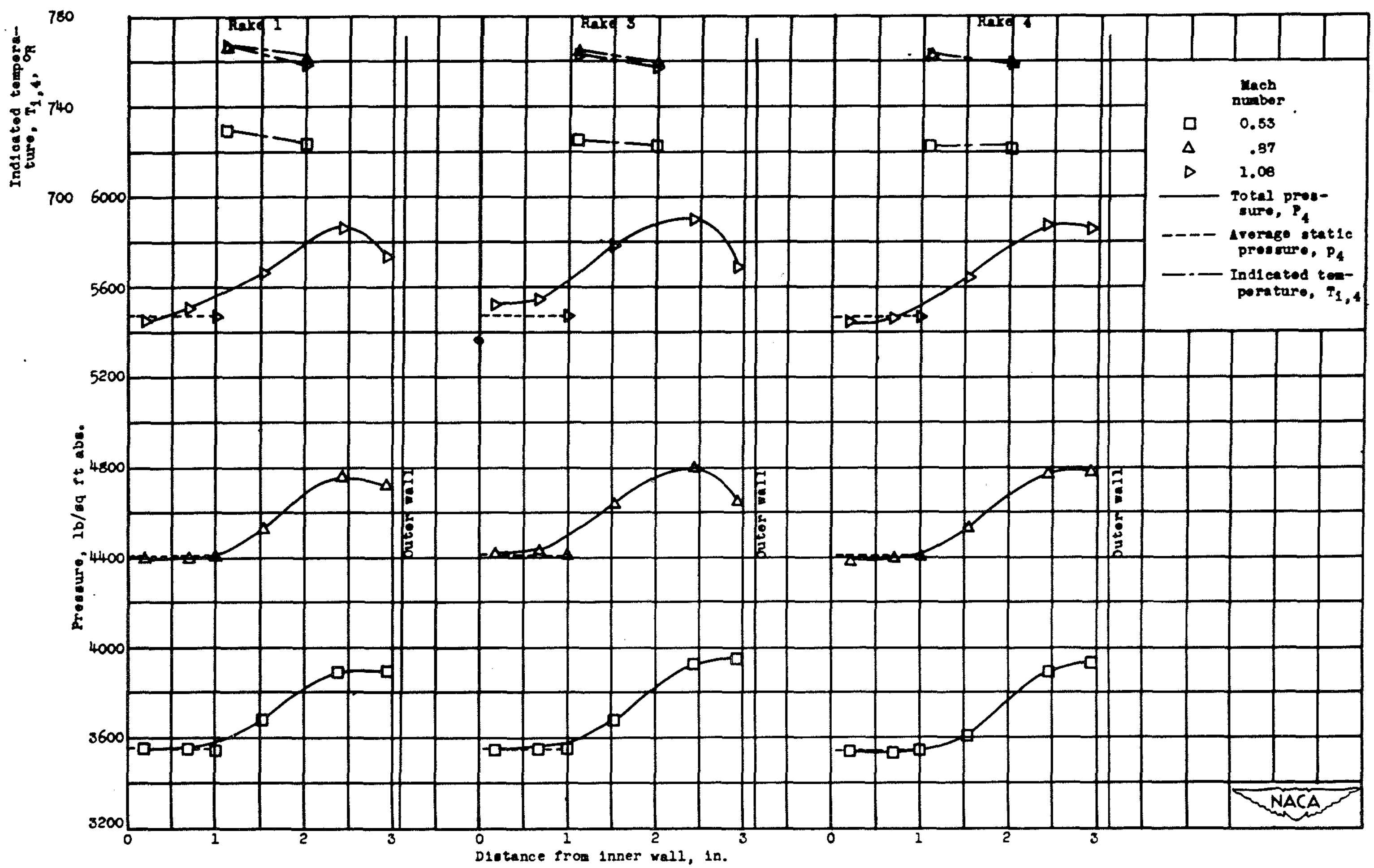

Figure 26. - Effect of Mach number on radial distribution of total pressure, static pressure, and indicated temperature at compressor outlet, station 4. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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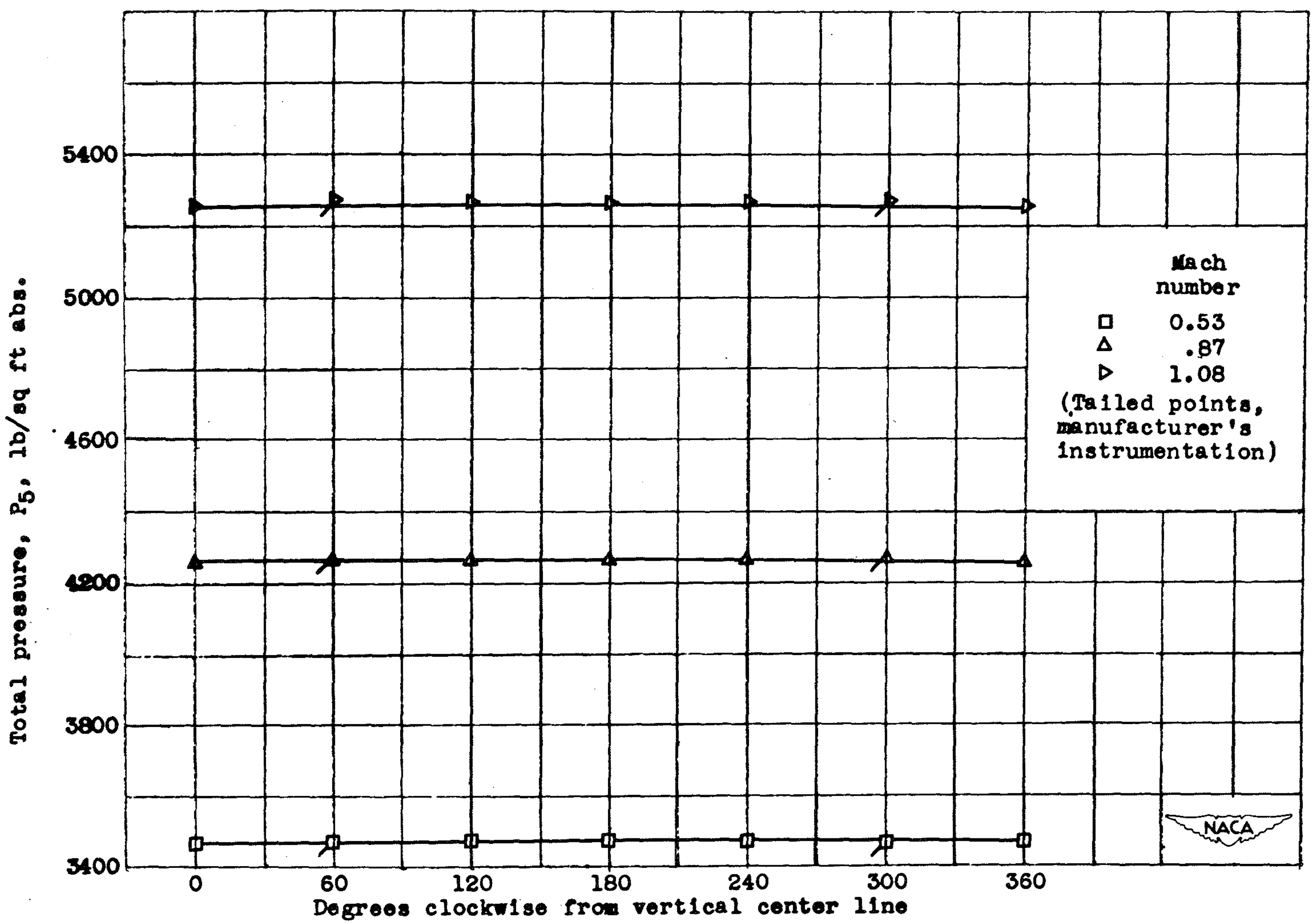

Figure 27. - Effect of Mach number on circumferential distribution of total pressure at turbine inlet, station 5. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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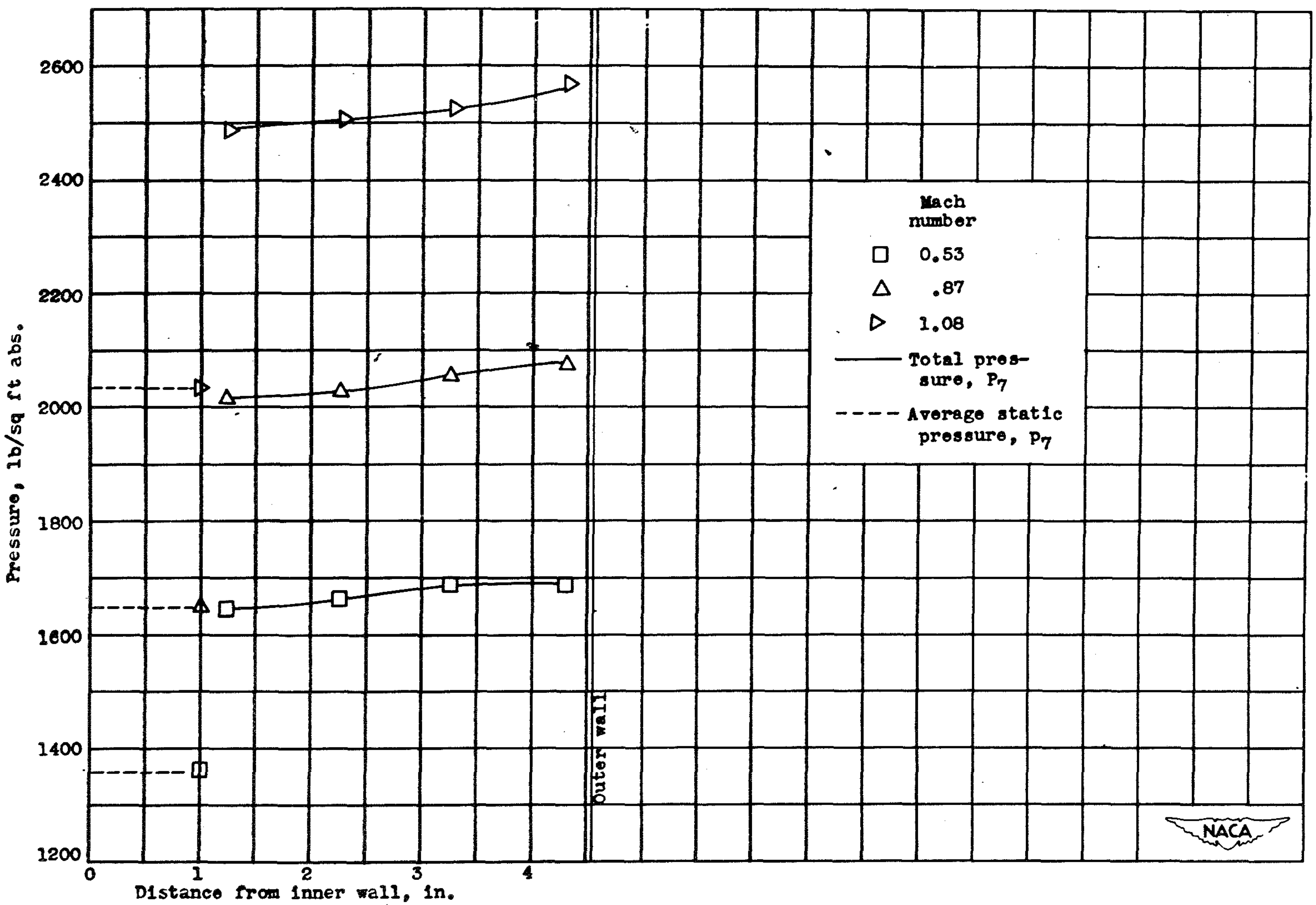

Figure 28. - Effect of Mach number on radial distribution of total pressure at turbine outlet, station 7. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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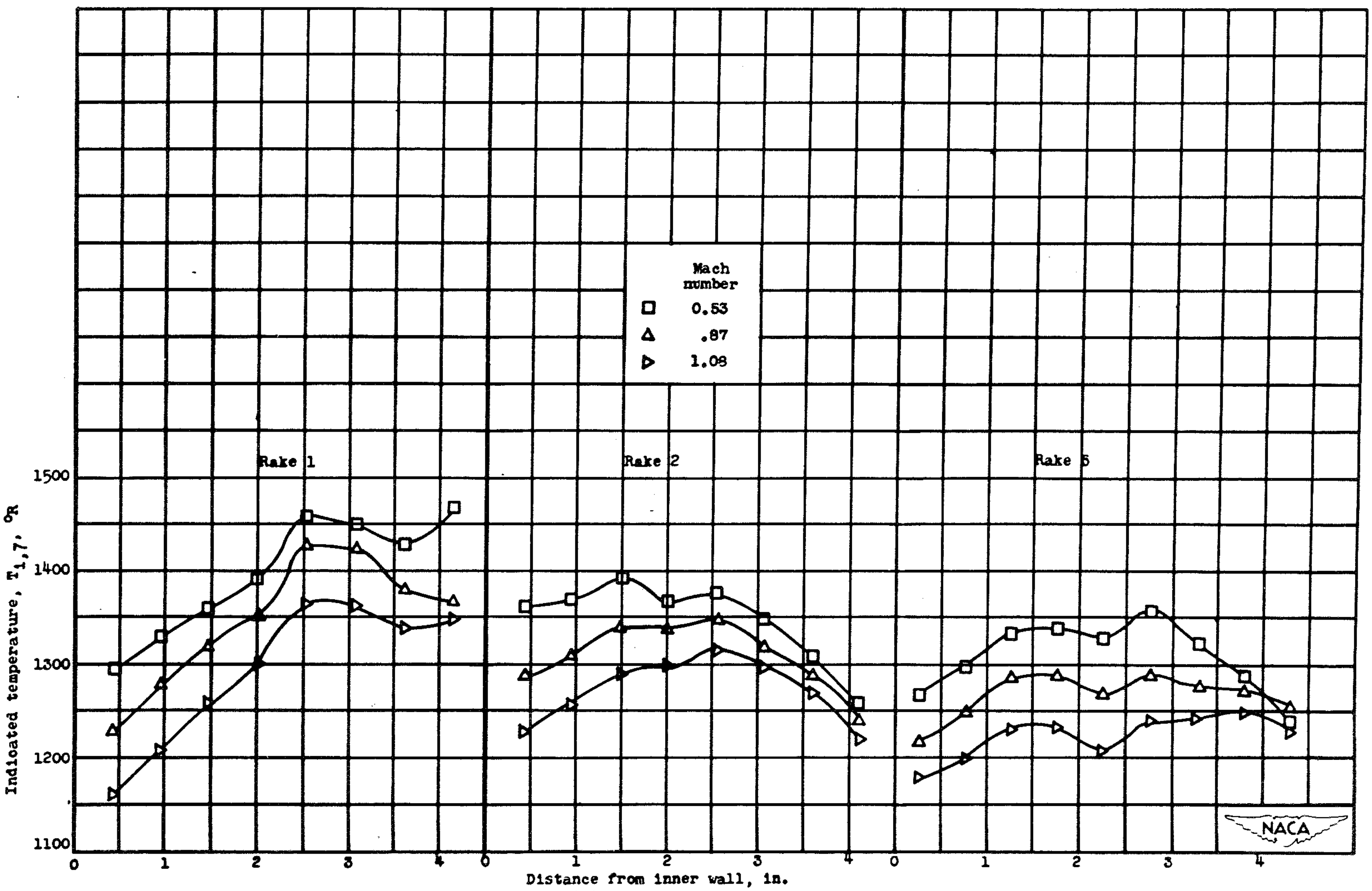

(a) Radial distribution.

Figure 29. - Effect of Mach number on indicated temperature at turbine outlet, station 7. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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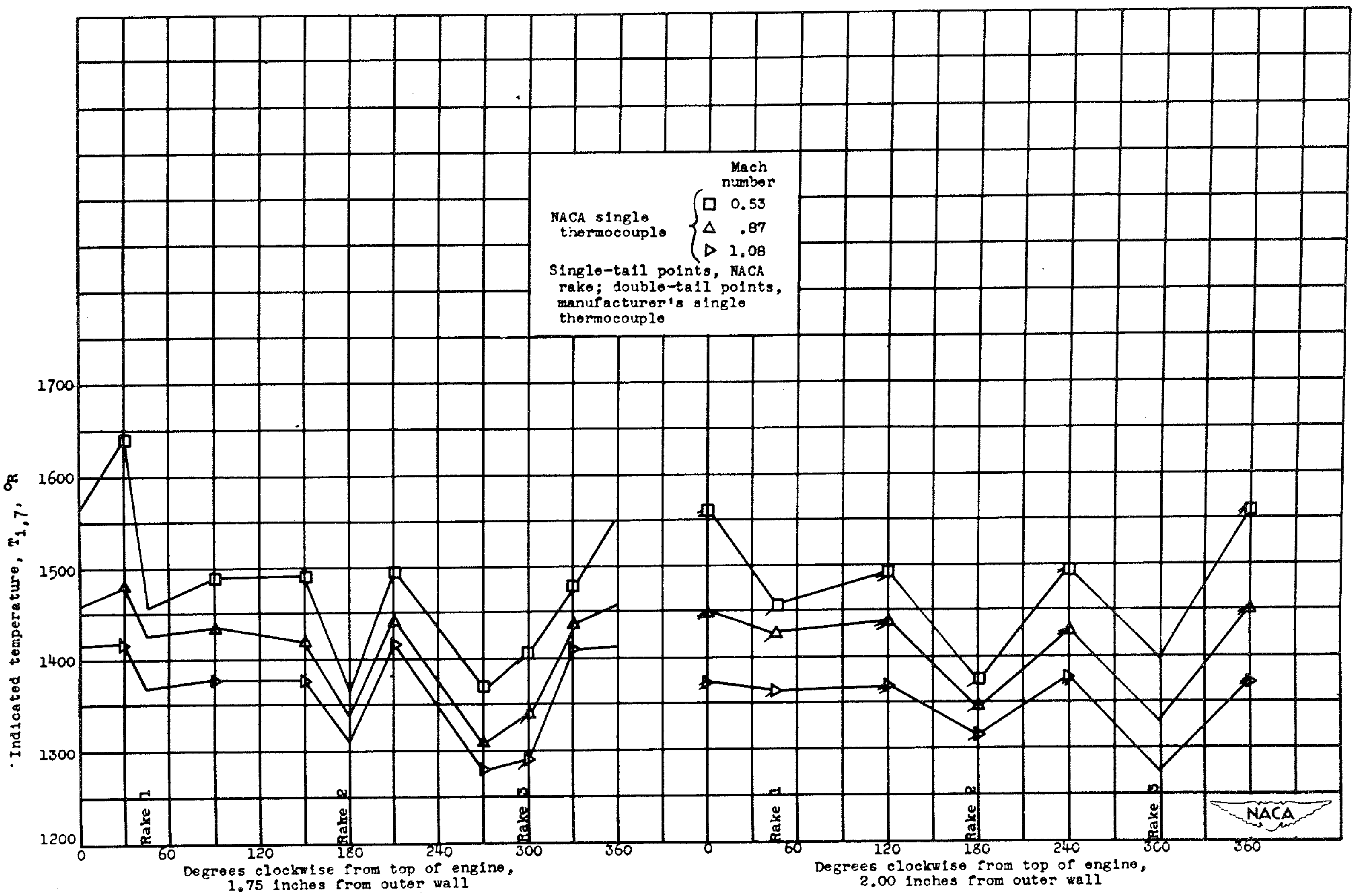

(b) Circumferential distribution.

Figure 29. - Concluded. Effect of Mach number on indicated temperature at turbine outlet, station 7. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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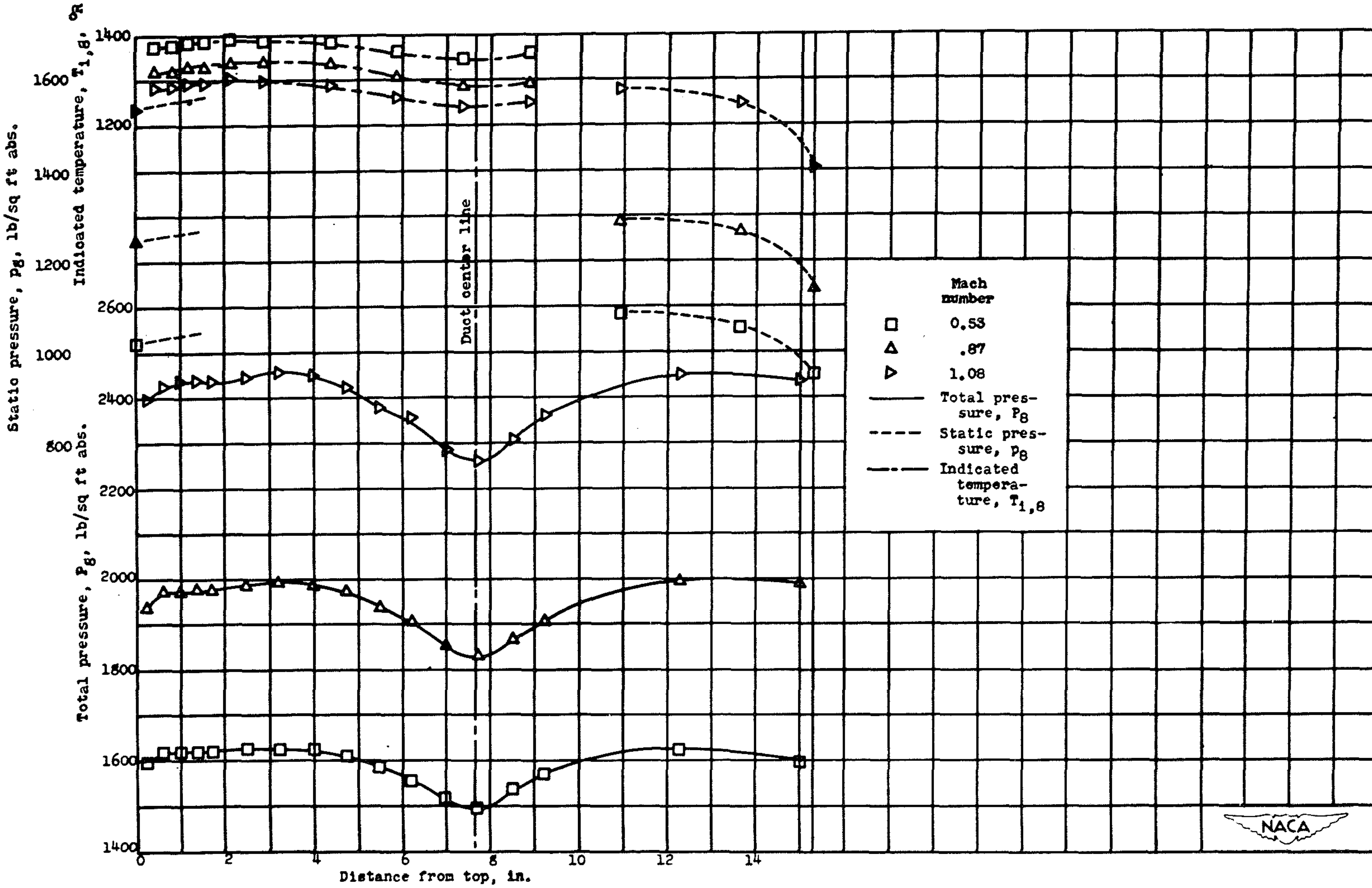

Figure 30. - Effect of Mach number on total pressure, static pressure, and indicated temperature at exhaust-nozzle outlet, station 8. Altitude, 25,000 feet; engine speed, 12,000 rpm.

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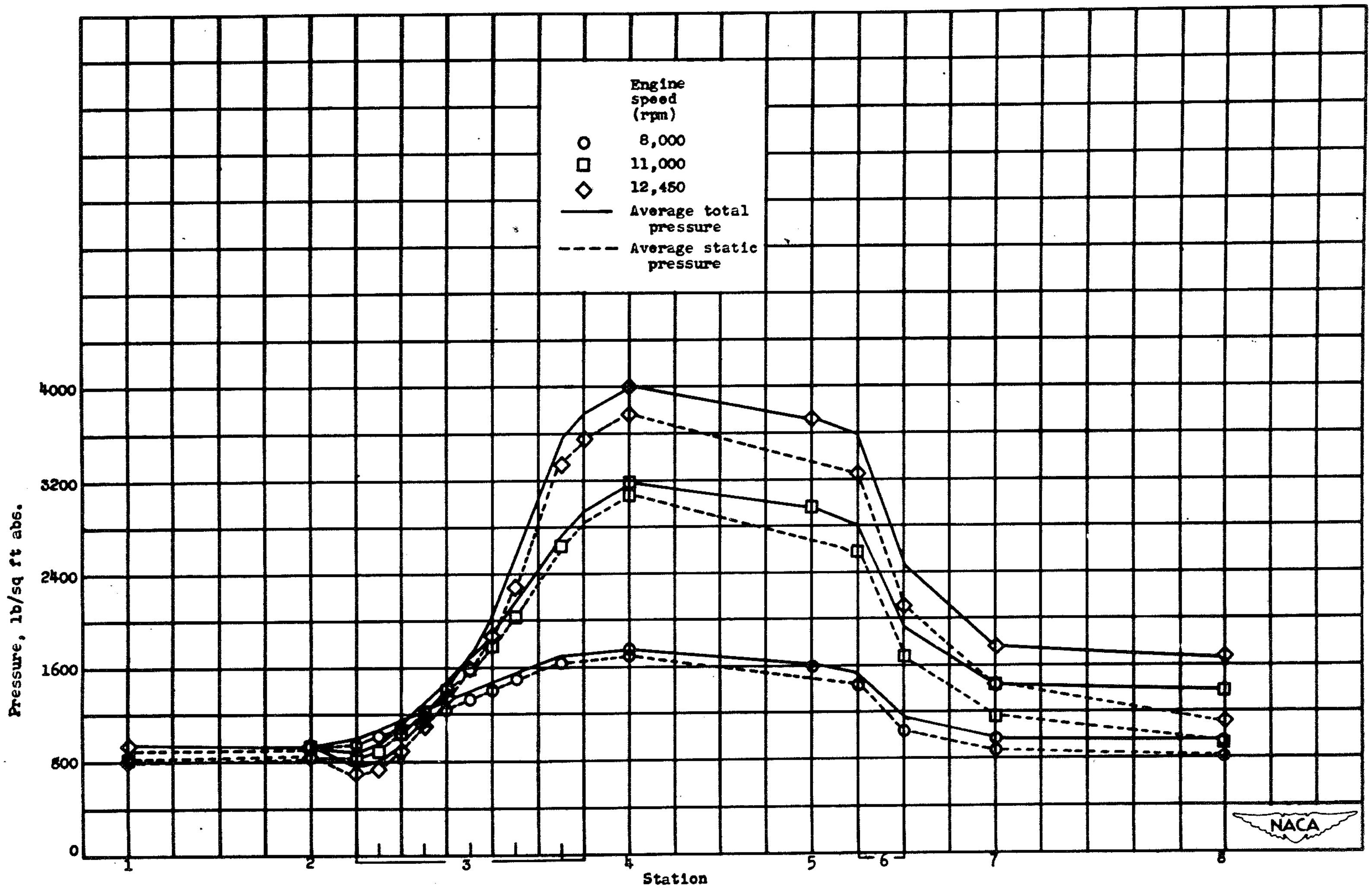

Figure 31. - Variation of average total and static pressures through engine with engine speed. Mach number, approximately 0.53; altitude, 25,000 feet.

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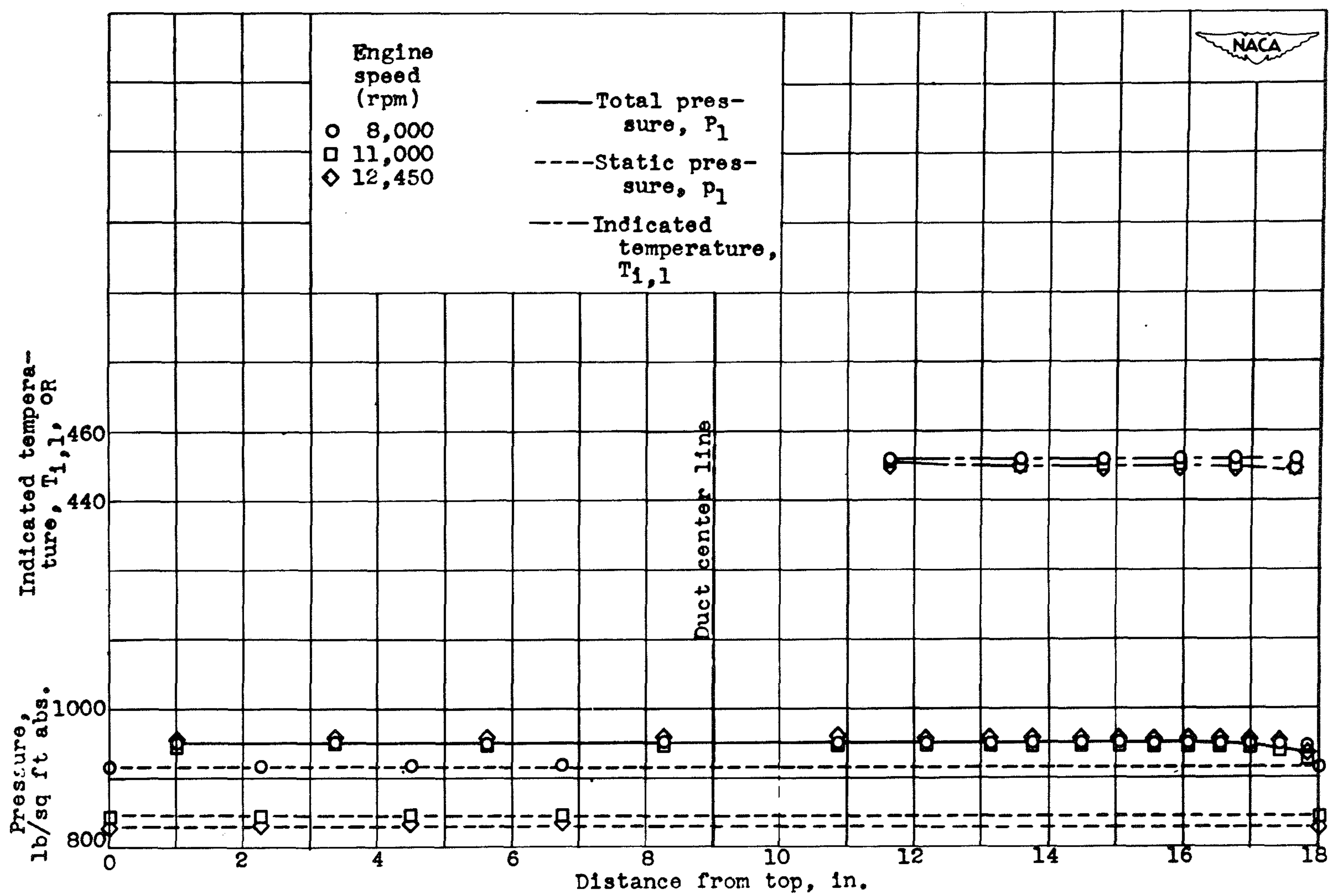

Figure 32. - Effect of engine speed on total-pressure, static-pressure, and indicated-temperature distribution at cowl inlet, station I. Mach number, approximately 0.53; altitude, 25,000 feet.

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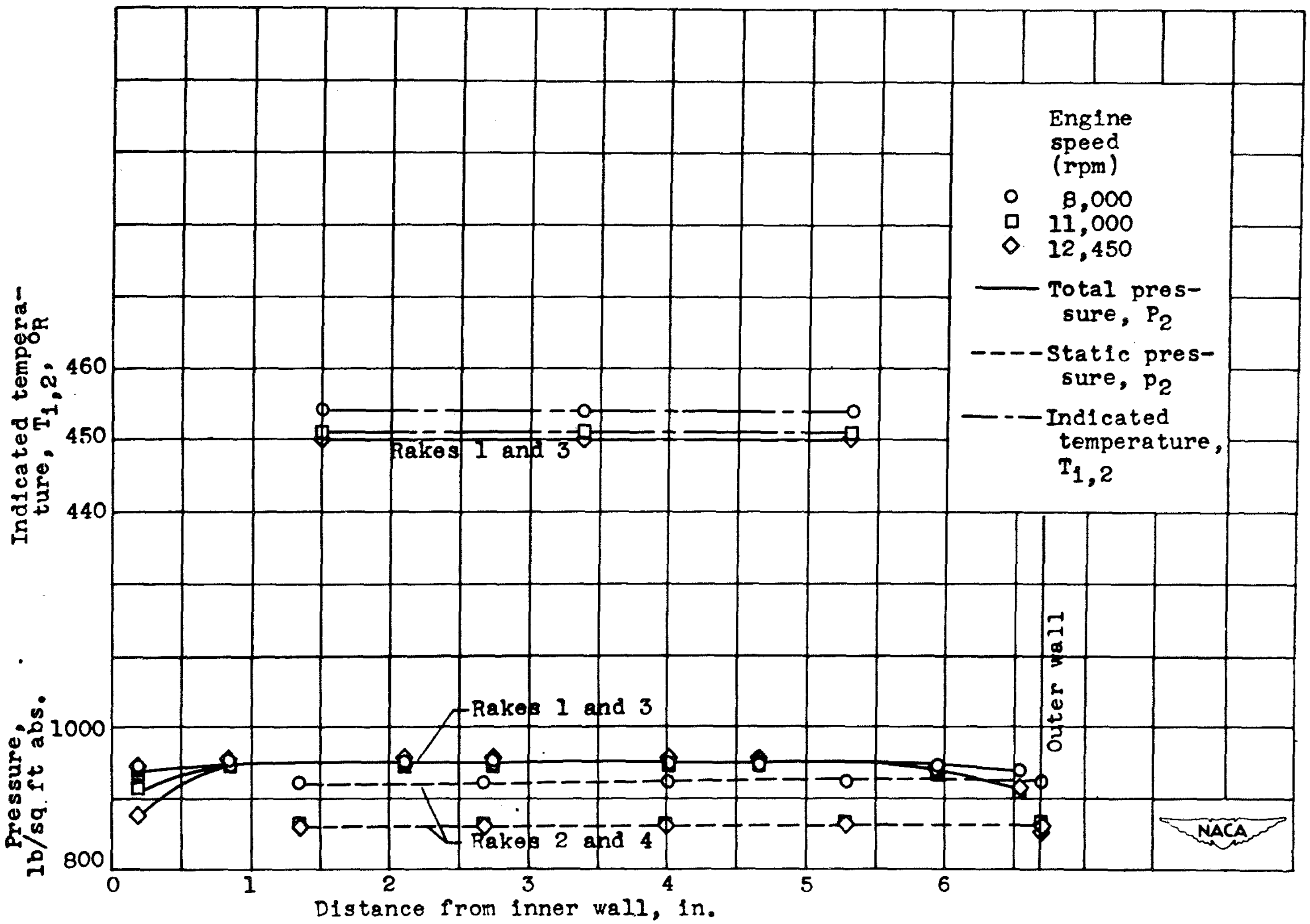

Figure 33. - Effect of engine speed on radial and circumferential distribution of total pressure, static pressure, and indicated temperature at compressor inlet, station 2. Mach number, approximately 0.53; altitude, 25,000 feet.

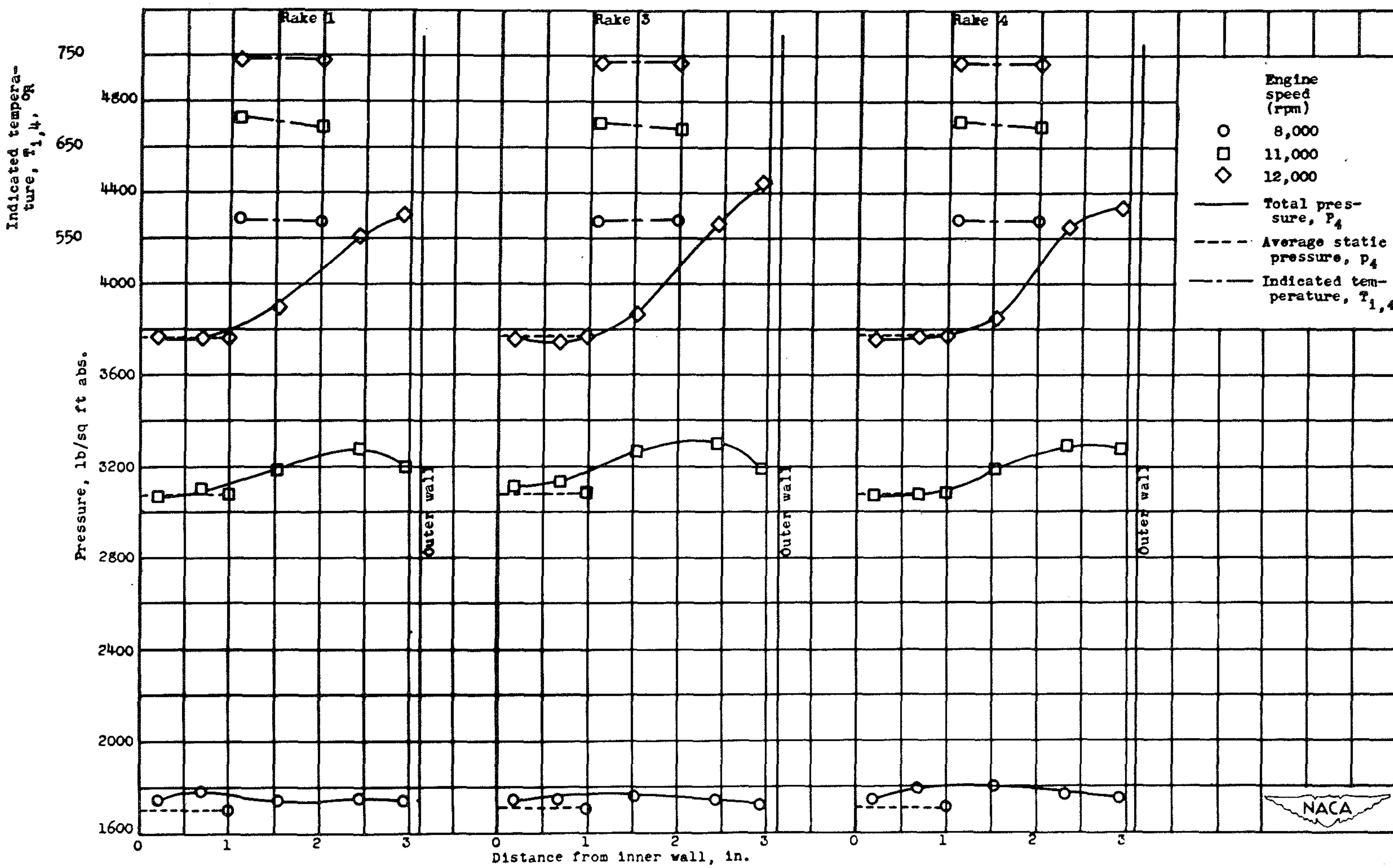

Figure 34. - Effect of engine speed on radial distribution of total pressure, static pressure, and indicated temperature at compressor outlet, station 4. Mach number, approximately 0.53; altitude, 25,000 feet.

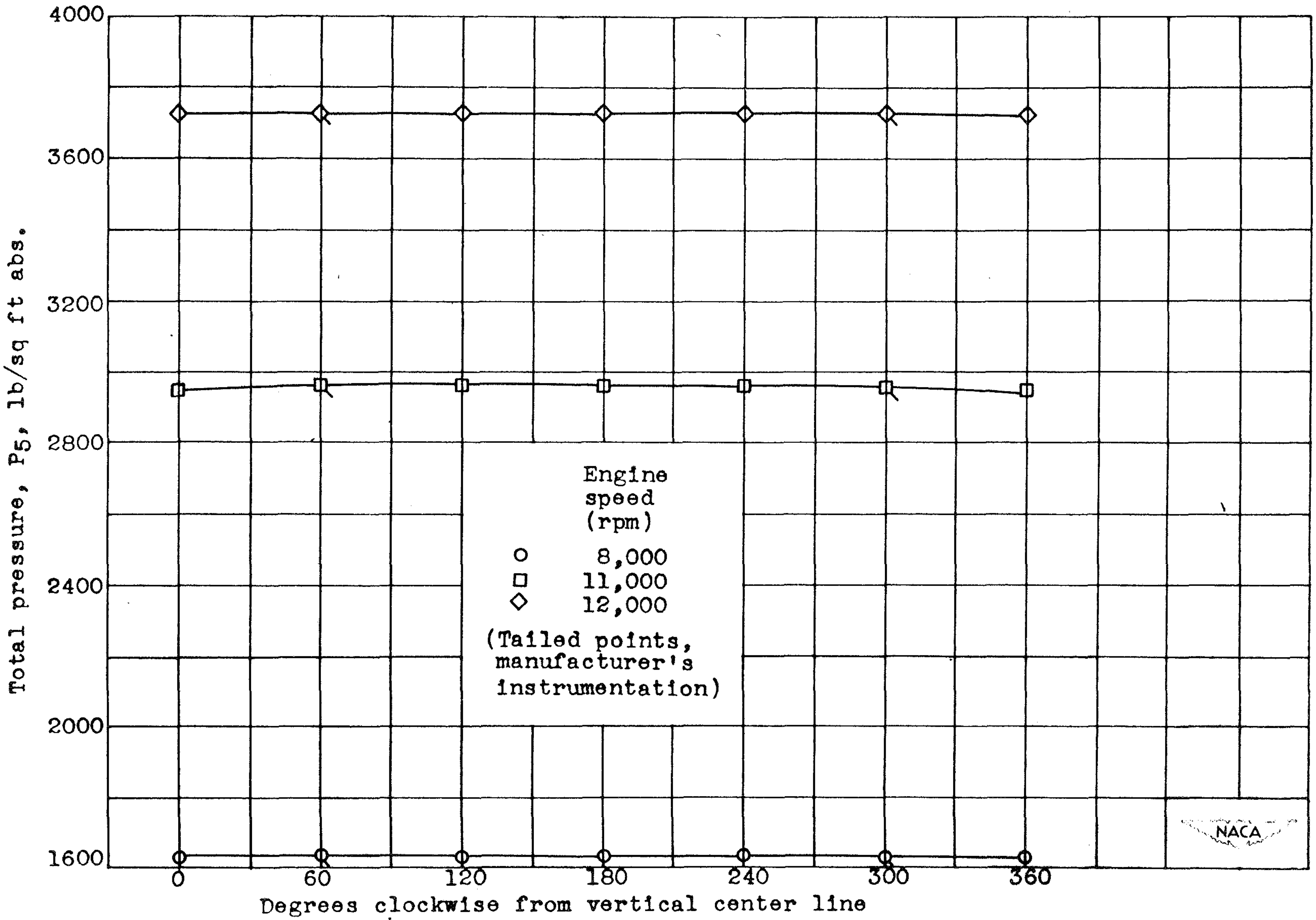

Figure 35. - Effect of engine speed on circumferential distribution of total pressure at turbine inlet, station 5. Mach number, approximately 0.53; altitude, 25,000 feet.

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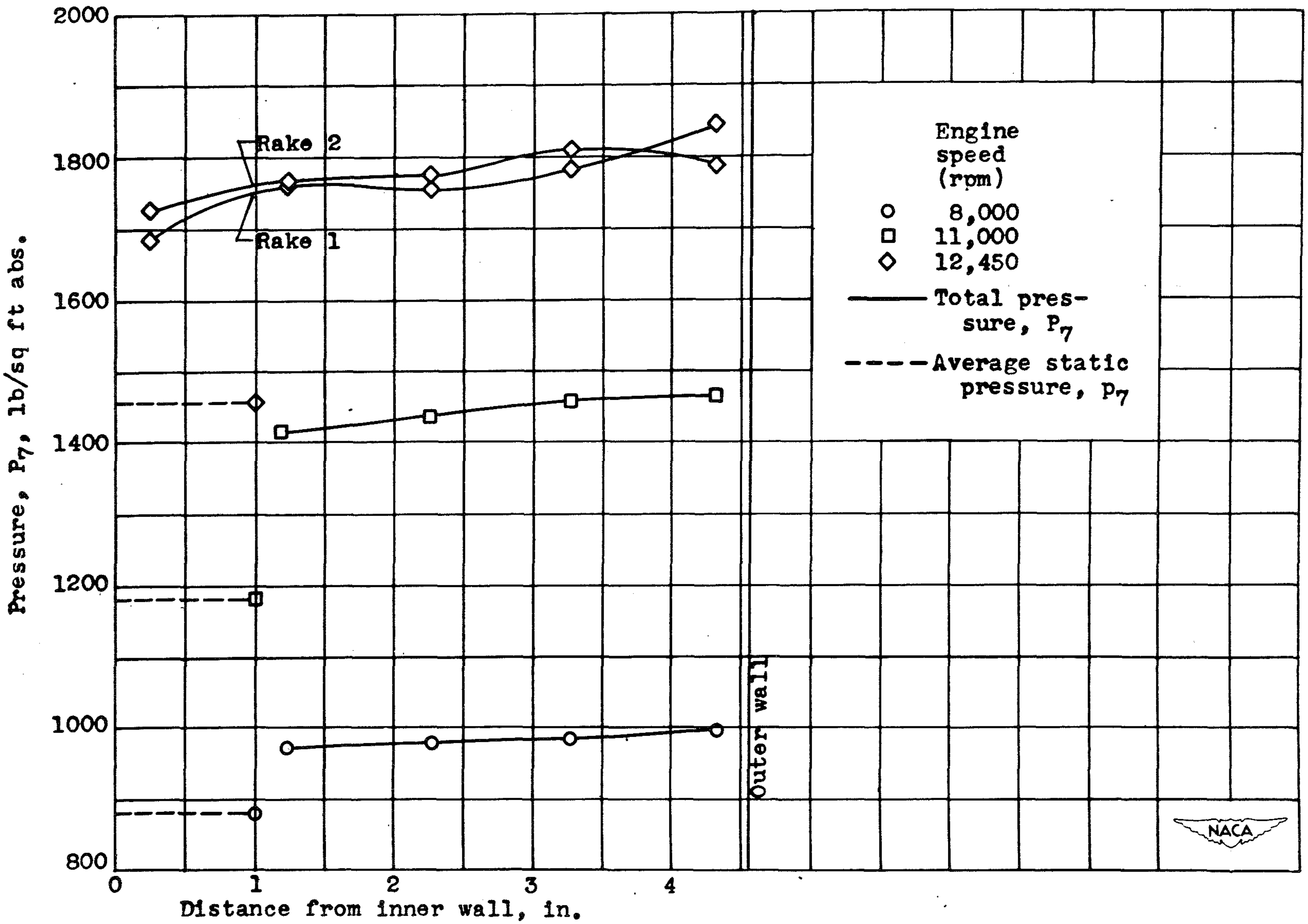
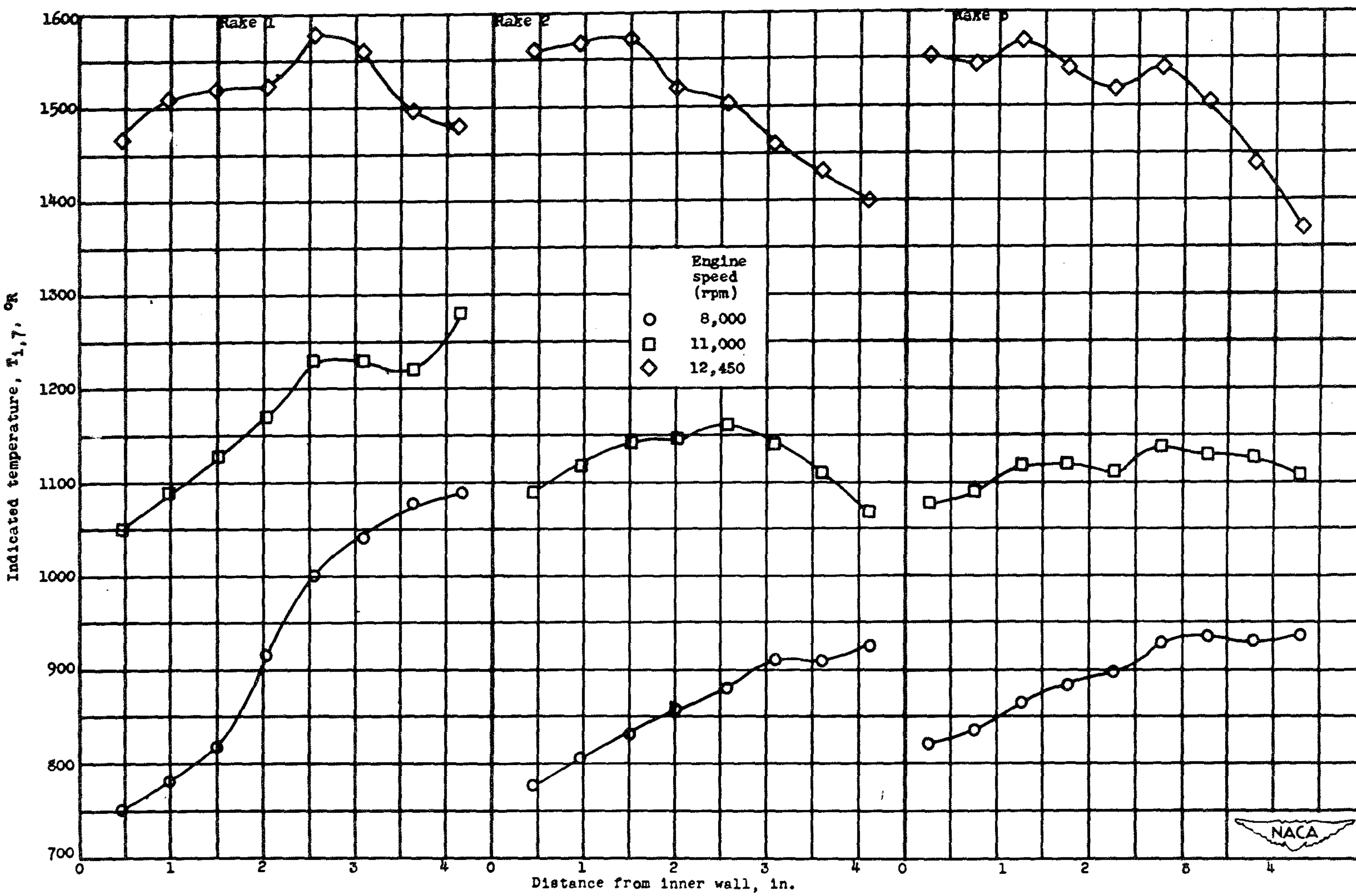
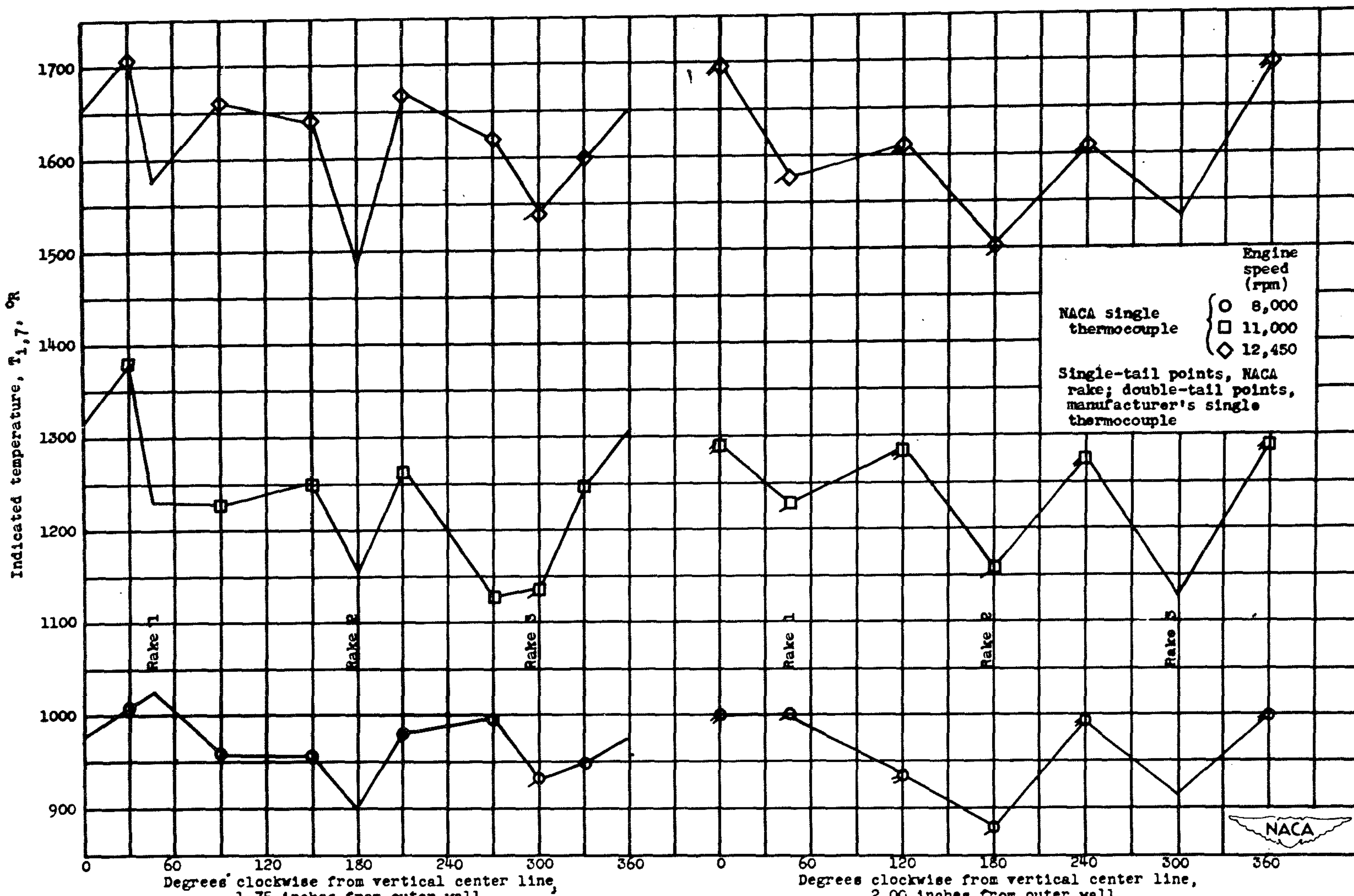


Figure 36. - Effect of engine speed on radial and circumferential distribution of total pressure at turbine outlet, station 7. Mach number, approximately 0.53; altitude, 25,000 feet.



(a) Radial distribution.

Figure 37. - Effect of engine speed on indicated temperature at turbine outlet, station 7. Mach number, approximately 0.53; altitude, 25,000 feet.



(b) Circumferential distribution.

Figure 37. - Concluded. Effect of engine speed on indicated temperature at turbine outlet, station 7. Mach number, approximately 0.53; altitude, 25,000 feet.

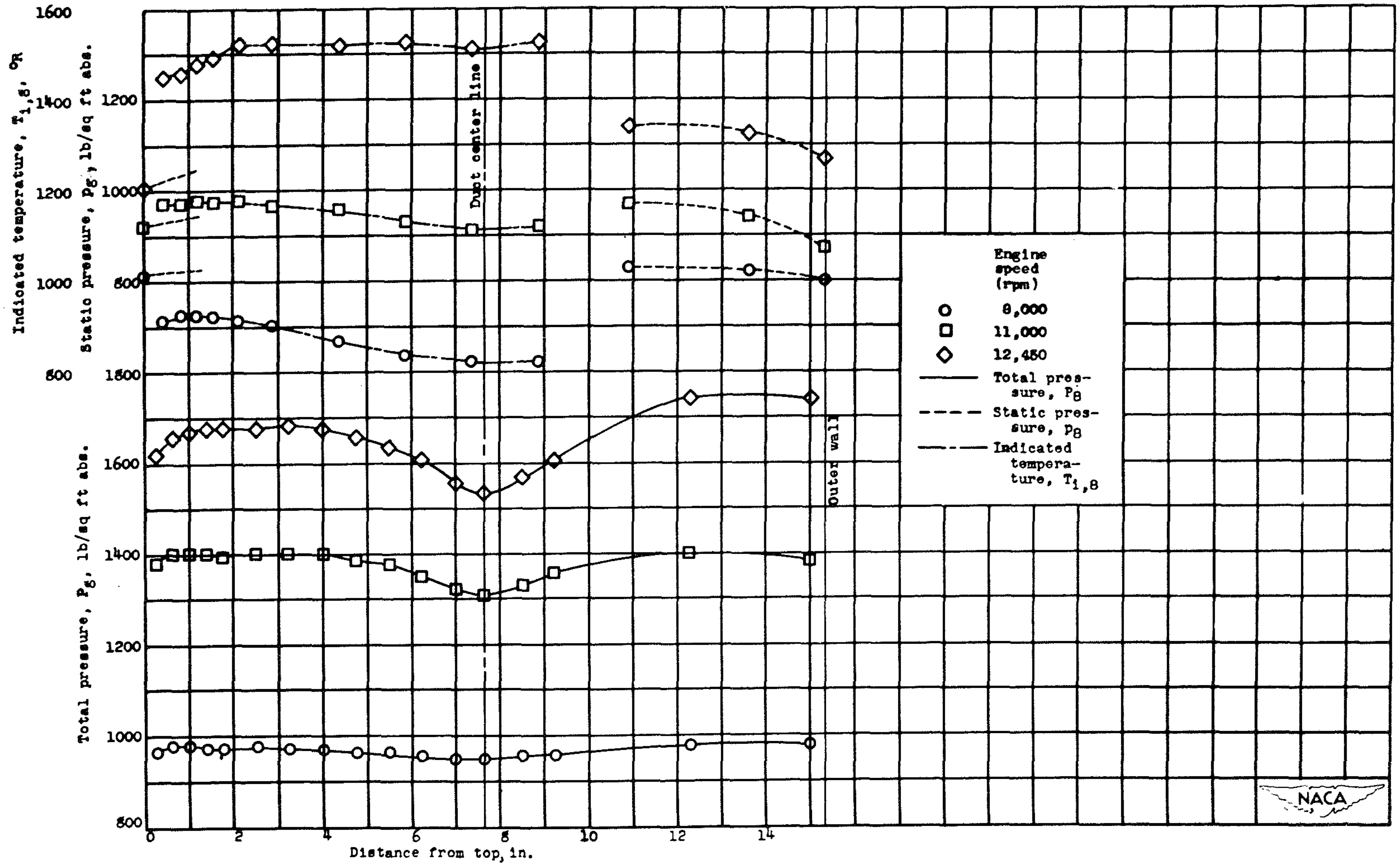


Figure 38. - Effect of engine speed on total pressure, static pressure, and indicated temperature at exhaust-nozzle outlet, station 8. Mach number, approximately 0.53; altitude, 25,000 feet.

Restriction/Classification Cancelled